THE MANUFACTURE OF CHOCOLATE AND OTHER CACAO PREPARATIONS

Paul Zipperer

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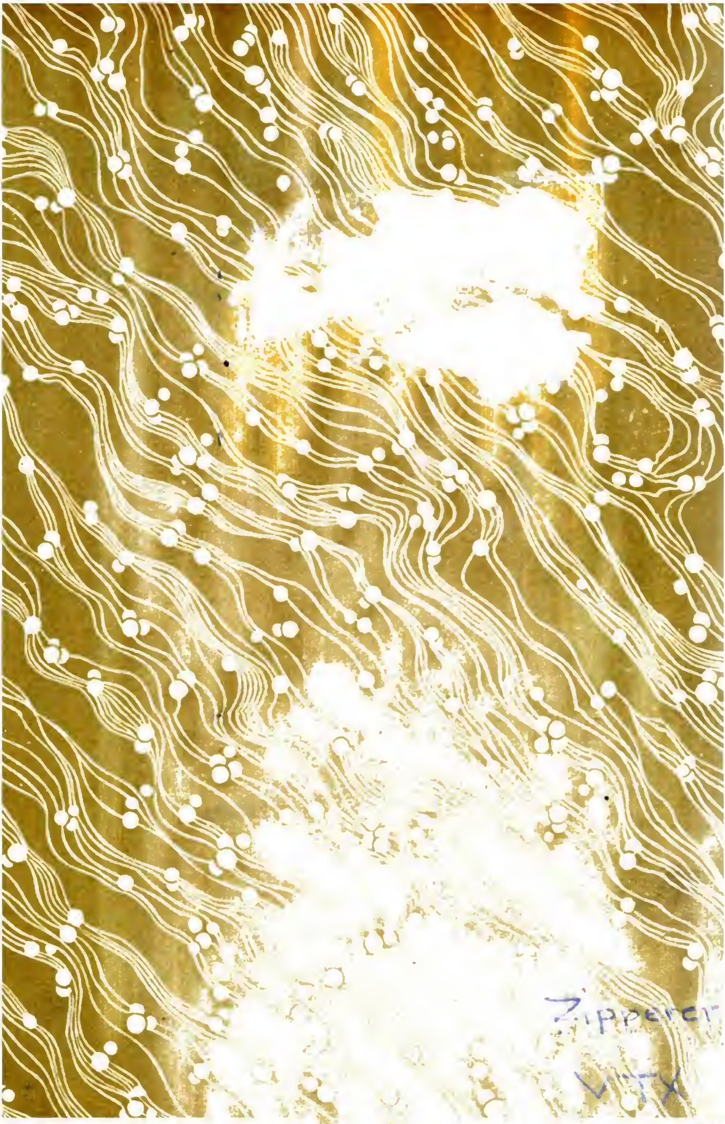

Zipperer
VIIX

THE

MANUFACTURE

OF

CHOCOLATE

AND OTHER CACAO PREPARATIONS

BY

DR. PAUL ZIPPERER.

SECOND EDITION

REARRANGED, THOROUGLY REVISED, AND LARGELY REWRITTEN.

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Preface to first Edition.

The object of this work is to furnish a source of information and advice for those who are interested in the branch of industry to which it relates.

The author has therefore endeavoured not only to describe the methods of manufacture; but has also given special attention to making known the nature of the raw materials employed, by reference to the literature on that subject, as well as by providing a precise account of the chemical composition of those substances and discussing the consequently necessary procedure to be observed in the manufacturing operations.

The art of chocolate making is no longer the same as it was some twenty or thirty years ago; but it has for the most part passed from small operators into the hands of large manufacturers.

A short historical resumé will suffice as a sketch of that development and a cursory description of some forms of apparatus which have now merely historic interest will serve to show how improvement in the industry has been effected.

Chocolate is a favorite and most important article of food and in that sense it is subject to legal regulations of which account must be taken, together with the most suitable analytical methods by means of which a manufacturer can ascertain the presence of unlawful admixtures in competing products, so that with knowledge of the regulations in force, he may also be prevented from infringing them even unintentionally.

Scientific formulæ and principles have been referred to only in those instances where necessity required and when that was unavoidable it has been done in such a manner as to be readily intelligible even to manufacturers without scientific knowledge.

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The author takes this opportunity of acknowledging his obligation to the Association of German chocolate makers for the assistance so generously afforded to him in the preparation of this work. He also trusts that his earnest endeavour to disseminate right views on the subject will secure for the work a friendly reception and appreciation.

Preface to second Edition.

Within the ten years that have passed since the first edition of this work appeared the manufacture of chocolate has undergone very great expansion. Not only has the mode of operating been simplified and improved, by the introduction of a number of new mechanical appliances, but the knowledge of the subject has been extended, from the chemical and microscopical points of view, to such a degree as to furnish in part a new basis for judging of cacao constituents and cacao preparations. The author has endeavoured to take into account all those advances, in the revision of the work, so as to collect together material scattered through various journals, to compare and supplement the information there given, in order that all who are interested in this industry might have a complete representation of the actual condition of the chocolate manufacture, **not only the makers but also the food analyst and the engineer.**

The arrangement and treatment of the matter are essentially the same as in the first edition. In consideration of the importance that has recently been acquired by some branches of the industry, such as the preparation of cacao powder, soluble cacao, cacao butter, pralinés and chocolate creams, space has been given for descriptions of the respective details. On the other hand no attempt has been made to introduce calculations as to the cost of producing the various cacao preparations, since statements to that effect are capable of giving rise to more detriment than utility. The cost of manufacture is subject to great variation, according to the scale on which it is carried out, so that estimates made on the basis of large operations might eventually lead to the conclusion that a small factory might be profitable and with no better result than that of creating undue competition in prices and eventual failure. Moreover, the fluctuations in the market price of cacao and of sugar are so frequent and there is such possibility of new sources of expense that calculations can apply only to the time they are made; they soon become out of date and then afford no trustworthy indication of probable profit and loss.

The section treating of legislative regulations relating to the trade in cacao preparations has undergone complete revision to adapt it to existing conditions. To render the book more useful, an appendix has been added in which the production and composition of several cacao preparations are treated of, so that the book may be used for reference in that respect.

The German edition having been out of print for nearly a year, some new and valuable contributions to the knowledge of cacao which appeared in the meanwhile must be likewise taken into consideration. They are duly noticed in these pages as well as the improved type of machines and thus the English edition has been brought up to date.

As in the case of the first edition the author has had the good fortune to have valuable assistance from the Association of German Chocolate Makers; from Professor Dr. H. Schenck of the technical high school in Darmstadt, Messrs. J. M. Lehmann, machine makers of Dresden and from P. Welmans chemist to the firm of Gebrüder Stollwerck at Cologne, to all of whom he is indebted and offers his hearty thanks.

Darmstadt, October 1902.

Dr. Paul Zipperer.

Contents.

Page:

I. Geographical distribution, history and cultivation of the cacao tree.

General observations on the geographical distribution of the cacao tree. — Development of its culture in Ceylon. — Its first appearance in history. — Introduction into Europe. — Cultivation-Diseases of the cacao tree 1

II. Description of the cacao tree and its fruit; collecting the fruit; fermentation 7

Botanical description of the organs of vegetation. — Collection of the fruit. Unfermented and fermented beans. — Constitution of the kernels before and after fermentation. — Utilization of the various organs of vegetation of the cacao tree.

III. The cacao bean 13

Commercial varieties. — External form and microscopic structure. — Mitscherlich-particles. — Contents of the cells.

IV. Commercial sorts of cacao beans 17

Commercial kinds and their distinguishing characters. — American Cacao (Venezuela, Ecuador, Caracas, Puerto Cabello, Ariba-Guayaquil, Machala-Guayaquil, Surinam, Brazil, Cuba, West Indies). — Asiatic Cacao (Ceylon, Java). — African Cacao (Cameroon, St. Thomé, Principe, Fernando Po).

V. The trade in cacao and the consumption of cacao products . . 27

Statistics of the import and export of cacao and cacao products in various countries (Germany, England, France, North America, Holland). — Commercial value of cacao preparations. — Relative consumption of coffee, tea and cacao.

VI. The chemical constituents of the cacao bean 32

General observations. — Chemical analyses of the raw shelled bean and of the roasted shelled bean. — Chemical constituents of the cacao bean:

1. The water or moisture 35
   Determination of water.
2. The fat 35
   Extraction. Chemical determination. Physical properties. Rancidity. Specific gravity. Determination of melting point. Detection of adulteration. Analytical methods for the investigation of the fat: iodine value, saponification value, acid value, Reichert-Meissl value, refractive index. Shell butter. The various adulterants. — The use of cacao butter and its trade.
3. Cacao red or pigment 46
   Chemical nature of cacao red. Formation and de-composition. Properties and determination.
4. Theobromine 48
   Chemical nature and synthesis of theobromine. Physiological action. Therapeutic use. Quantitative determination. Properties.

Page:
5. Albumin 54
Properties of proteins. Analytical determination. Digestibility and utilization in the human organism.
6. Starch 58
Botanical. Gelatinization. Iodine reaction. Inversion. Chemical determination.
7. Cellulose or Crude fibre 62
Methods of determination: Weender-process. König-Filsinger's method.
8. Sugar and plant acids 64
9. The mineral or ash constituents 64
Analytical results of the ash of various kinds of cacao. Occurrence of globoids and of copper in the ash.

VII. The cacao shells 66
Chemical constituents. Analyses of the ash. Methods of determination of the constituents of the shells. Microscopic investigation. Use of the shells.

VIII. Ingredients used in the manufacture of chocolate 75
General observations.
1. Sugar 75
Grinding and sifting machines for sugar and spices.
2. Saccharin and other artificial sweetening materials 81
Chemical determination of Saccharin in Cacao powder.
3. Starch etc. 82
Potato starch, wheat starch, dextrin, rice starch, arrowroot, chestnut meal, bean meal, salep.
4. Vanilla 85
Origin. Cultivation and preparation. Adulterations. Determination of vanillin.
5. Vanillin 88
Occurrence. Artificial preparation. Commercial value. Adulteration and its detection. Its employment as a substitute for vanilla
6. Cinnamon 91
Ceylon, Cassia, Malabar. Adulteration.
7. Cloves 92
8. Nutmeg and mace 92
9. Cardamoms 92
10. Ethereal oils 93
Employment in place of spices. Theobrominat.
11. Peru balsam and gum benzoin 95
Chemical constituents and adulterants. Chocolate varnish and confiture lac.
12. Colouring materials 96
Permitted natural colours. Permitted aniline colours. Fat-soluble colours.

Manufacture of cacao preparations.

IX. Manufacture of chocolate 98
General and historical remarks on the preparation of the beans.
1. Storing, cleansing and sorting the beans 98
Storage. Damaged beans and their treatment in the magazine. "After-fermentation". Cleansing in revolving casks and in cylindrical screens. Lehmann's cleansing and sorting machines.
2. The roasting of the beans 103
The object of roasting. Methods of roasting. Lehmann's roasting apparatus. "Salomons double centrifugal roaster". Steam roasting. Cooling and exhaust arrangements.

Page:
3. The crushing, shelling and cleansing of roasted beans . . 109
Lehmann's crushing and cleansing machines. Working results of these machines. Machine for removing the radicles. Dust cleansing machine. Advantage and economy of these new machines. Chemical composition of the waste product.
4. Mixing different kinds of cacao beans 117
The object of mixing. Proportion of such mixtures.
5. Trituration of the cacao mass 125
Lehmann's new cacao mill. Simple, twin and triple mills.
6. Mixing the ground cacao mass with sugar and spices to produce chocolate 123
The principles on which the trituration depends. Lehmann's preliminary mixer. Hermann's rotating stone machine. Melangeurs with rotating and fixed bed stone. Cylindrical rolling machines. Batteries of rolling machines. Lehmann's six and nine roller machines. Recipes for chocolate. Mixtures for chocolate mass.
7. Preparation of "chocolates fondants" (Chocolate creams) . . 139
Lehmann's longitudinal triturating machine and its effects. "Conches" and their use.
8. Heating chambers and closets 142
9. Removing air and division of the chocolate 144
Preparation of chocolate in the one armed mixer; machines for removing air.
10. Chocolate moulds and the moulding of chocolate 147
The moulds and the moulding of various forms of chocolate. Chocolate cigars, eggs, various other forms. Crumb chocolate. Tablets etc. with cream filling. The shaking and tapping table. Lehmann's new shaking table with controlable movement, etc. Shaking table system with common driving power. Double hoists.
11. Cooling the chocolate 156
Object of cooling. Judgment of well cooled products. The cooling cellar and its plant. Artificial cooling appliances with compressed carbonic acid according to the system of Wegelin and Hübner. French cooling apparatus. Douane's Ethyl chloride and T. & W. Cole's cooling arrangements.
12. The preparation of chocolate tablets and pastilles 164
Development of this branch of the industry. A. Reiche's chocolate pastille machines.
13. The preparation of coated goods 167
Historical. Preparation of "fondants". Lehmann's Fondant-machine. Lehmann's powdering machine with striking blast. The coatings and their preparation. The coating of pralinés. Reiche's praliné machine. Lehmann's dipping machine.

X. The manufacture of cacao powder and "soluble" cacao . . . 178
Historical. Soluble cacao.
1. The various methods of making cacao soluble and their different stages 178
The Dutch method.
2. The expression of the cacao butter 182
Historical. The hydraulic presses. Filtering the cacao butter. Columnar presses with Lehmann's accumulator. Hydraulic presses with 300 atmospheres pressure for separation of fat.
3. Powdering and sifting of the cacao, deprived of fat . . . 188
Pulverizers. The centrifugal cylinder-sifting machine. The preliminary crusher. Lehmann's automatic pulverizing plant. Moser's process for rendering the cacao soluble.
4. Rendering cacao soluble after roasting 194

Page:

a) before pressing 194

The universal kneading and mixing machine of Werner and Pfleiderer.

The use of alkalies 195

Fixed and volatile alkalies. Selection and proportion of alkali. Solution of the alkali and its mixture with the cacao mass. Removal of the solvent material. Further treatment of cacao in the press and the pulverizer.

b) Rendering cacao soluble after pressing 198

Preparatory treatment. Impregnation of the pressed blocks of cacao with alkali, drying and pulverizing.

Rendering cacao soluble without the use of alkalies . . .

Lobeck's Steam-process, Gaedke's process.

General considerations as to the methods of making soluble cacao 199

Characters of soluble cacao. Determination of the solubility. Aromatising soluble cacao. Weighing and packing cacao powder by means of Wagner's packet filling machine. Composition of the powdered cacao. Analyses of soluble cacao, prepared by different methods. Conclusions to be drawn from the amount of ash in soluble cacao. Consideration as to the addition of fixed alkalies from the hygienic point of view. Adulteration of powdered cacao with powdered shells. Ascertaining the amount of shell.

XI. Storing and packing the finished cacao preparations 206

Suitable storage. Materials for packing. Formation of mould in the stored materials.

XII. Arrangements for transport 208

Elevators. Raising machines with double carrying bed. Arrangement of hoists.

XIII. Motors 210

Generalities. Water power plant. Working cost of a horse power in small factories. Steam engines. The Dieselmotor. Comparison of the hour horse power in the case of various motors. The Dawson gasmotor. Application of different motors. Electromotors. Classification and advantages of the working in groups in the manufacture of chocolate.

XIV. Plants of a chocolate- and cacao powder factory 215

General remarks. Arrangement of a chocolate factory with reference to the section in plate I (appendix). Arrangement of a cacao powder factory with reference to the section in plate II (appendix).

XV. Chemical and microscopical examination of cacao preparations . 218

I. Chemical examination . . . .

a) Determination of water. Detection of gelatin according to Onfroy. Tragacanth,
b) determination of ash,
c) determination of silica in the ash,
d) determination of added alkali.
e) determination of fat. Welmans's agitating method, determination of melting point, the iodine-, acid-, saponification- and refractometer-numbers, etc.,
f) determination of theobromine and caffeine,
g) determination of starch,
h) determination of cellulose (fibre),
i) determination of cacao shells,
k) determination of sugar. Revenue method, determination according to Woy's and Zipperer's methods. Dextrin determination.

Page:

II. Microscopic examination 228

Anatomical organs of cacao. Methods of examination. Detection of foreign starch and cacao shells. Search for foreign vegetable materials.

III. Taking samples 231

IV. Definition of cacao preparations 231

Chocolate, cacao mass, cacao powder, cacao butter, covering masses.

Adulteration of cacao preparations and means of detecting etc. .

Tabular statement of adulterations and methods of detection.

Valution of cacao preparations . . . .

Admissible and inadmissible admixtures. Calculation of analytical results.

XVI. Legislative regulations of the trade in cacao preparations . . . 236

The Belgian law. The Romanian law. The application of the Swiss "Lebensmittel" book and the Austrian "codex alimentarius". British laws: Sale of food and drugs act 1875 and the Amendment act 1879. The United States of America laws against adulteration of food products. The law of the German empire, relating to trade in food materials and the value of materials, on which it is based. Agreements as to uniform examination of food materials etc. in Germany. Suggestions as to legislative regulation of the trade in cacao preparations.

Appendix, containing analyses and recipes for the preparation of a large number of dietetic cacao products, such as acorn-, malt-, milk- and oat-chocolate or cacao etc. 250

Bibliographical references on Cacao cultivation and technology of cacao manufacture 264

Index 266

Illustrated plate I. Chocolate factory.

Illustrated plate II. Cacao powder factory.

Advertisements (Appendix).

Errata.

P. 96. — Last line: *for* and *read* nd.
P. 119. — Line 4 from bottom *for* homogenous *read* homogeneous.
P. 121. — Figure 27 *for* 100 Touren *read* 100 revolutions.
P. 123. — Line 8 from bottom *after* risk *insert* of.
P. 125. — Line 4 from top *for* and mixed *read* then mixed.
P. 125. — Line 2 from bottom *for* transpoite *read* transport.
P. 126. — Line 1 from top *after* granite work *insert* move.
P. 126. — Line 2 from top *after* also *insert* made.
P. 126. — Line 7 from top *for* d and d *read* d and d^1.
P. 127. — Line 10 from top *for* considerable *read* considerably.

I. Geographical distribution, history and cultivation of the Cacao tree.

The cacao tree flourishes in a warm moist climate. It is therefore indigenous to tropical America from 23° north to 15° or 20° south latitude.

Consequently the area in which it grows comprises, in tropical America, Mexico, the isthmus of Panama, Guatemala, the greater and lesser Antilles, Martinique, Trinidad, St. Lucia, Granada, Cuba, Hayti, Jamaica, Puerto Rico, Guadeloupe, San Domingo; in South America the central American republics of Venezuela, Columbia, Guiana, Ecuador, Peru and the northern part of Brazil, especially Parà.

In the other countries where the cacao tree now flourishes, it has been naturalized, either by colonists, or with government aid, as in Asia: in the Philippine islands, Javà, Celebes, Amboyna and especially in Ceylon, in Africa: in Cameroon (Bibundi, Victoria and Buea) also in Bourbon, Sao Thomé and the Canary islands, where the cacao tree is sometimes found growing at an elevation of 300 metres above the sea level. The chief sources of cacao at the present time are the British Colonies. Ceylon offers an instructive illustration of the zeal with which the cultivation of cacao is carried on in those localities. According to information furnished by Mr. Ph. Freudenberg the German Consul at Colombo, cacao had been planted, in a few instances, during the time Ceylon was in the possession of the Dutch, but only since 1819 has seed been supplied to the planters from the botanical gardens at Kalatura and subsequently from those at Peradenija. Systematic cultivation for commercial purposes commenced in 1872 or 1873. The principal seats of cacao plantations in Ceylon are Dumbara with about 4200 acres under cultivation; also Kurunegalla, Kegalla and Polgahawella (about 3600 acres), Northeast and West Matale (about 5300 acres), Urah (about 1700 acres), Panwila (about 1700 acres) together with smaller areas in Alagaha, Kaduganawa, Dolosbage, Hantane, Nilamba etc. According to statistical records the relation between the growth and export of cacao is shown by the following table which also shows the development of the cultivation:

Year:	Area under cultivation (acres):	Exports (cwts):
1878	300	10
1879	500	42
1880	3000	121
1881	5460	283
1885	12800	7247
1892	14500	17327
1895	18278	27519

In the sheltered valleys of tropical countries where the soft soil, rich in humus, is kept constantly moist by large rivers the cacao tree blossoms throughout the whole year. When growing wild it is generally isolated under the shadow of larger trees; when cultivated, the young trees are placed under the shelter of bananas and at a later period of their growth, shade is provided by the coral tree (Erythrina corallodendron or Erythrina indica) called "coffie-mama" by the Surinam Dutch and madre del cacao by the Spaniards. Since the cacao tree is much in need of the shelter furnished by those trees for its development it flourishes only when distributed among them and is seldom met with forming entire woods.

Like all other articles of human food, cacao has a history of some interest, the essential points of which are here summarized from the excellent work of A. Mitscherlich.*)

A knowledge of the cacao tree was first brought to Europe in 1519 by Fernando Cortez and his troops. He found in Mexico a very extensive cultivation of the cacao tree that had been carried on for several centuries. In the first letter from Cortez to Charles the fifth, he described the cacao beans as being used in place of money. Cortez applied to the cacao tree the name of Cacap, a word derived from the old Mexican designation

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*) See references at the end of the book.

Cacava-quahitl. The Mexicans called the fruit Cacavacentli, the beans Cacahoatl and the beverage prepared from them chocolatl (pronounced Tschocolatl) said to be derived from the root cacava or cacao and atl = water. The word cocoa, commonly used in England, appears to be of european origin and is probably only a corrupted form of cacao. Its use is calculated to lead to confusion as it is also applied to the entirely different products of the cocoa nut. The name of cacao will therefore be employed in conformity with the practice that has been recently adopted by J. Hinchley Hart.*)

The botanical definition of the typical form of the cacao tree which belongs to the family Büttneriaceae is referrible to Linnaeus who gave it the name Theobroma cacao (food of the Gods from theos = God and broma = food). Probably chocolate was a favourite beverage with Linnaeus and he may have read the treatise published in 1684 by the Paris physician Buchat, in which chocolate is spoken of as an invention more worthy of being called food of the gods than nectar and ambrosia. Clusius first described the cacao tree in his "Plantae exoticae". The taste for chocolate was soon spread throughout Spain by those who had returned from the new world; but not without some opposition, especially on the part of the clergy who raised the question whether chocolate might be partaken of on fast days on account of its nutritive properties. However it found an advocate in cardinal Brancatio who described it as an article belonging, like wine, to the necessaries of life and he therefore held that its use in moderation could not be prohibited. In 1624 Franciscus Rauch published a work at Vienna against the use of chocolate, suggesting that the monks should be forbidden to make use of it, as a means of preventing many excesses. About the commencement of the 17 th Century the use of chocolate spread from Spain to Italy where it was introduced to notice in 1606 by the Florentine Antonio Carletti, who had resided for some time in the Antilles. The method of converting cacao beans into chocolate was also made known throughout Europe by Carletti, while the Spaniards had kept it secret. Under Theresa of Austria the consort of Louis XIV, the use of chocolate appears to have become very general in France after cacao had been introduced to some extent by importation from Spain. The first importation of cacao grown in the French colony of Martinique reached Brest in October 1679 in "Le Triomphant" the flagship of admiral d'Estrées. Opinion in France as to chocolate was then divided; Madame Sévigné who had at one time been an admirer of chocolate, afterwards wrote to her daughter: "il vous flatte pour un temps et puis il vous allume tout d'un coup une fièvre continue, qui vous conduit à la mort."

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*) „Cacao", a treatise on the cultivation and curing of „cacao", Trinidad 1900, II. Ed.

Chocolate was in general use about the middle of the 17th Century in England. Chocolate houses were opened in London similar to the Coffee houses of Germany. The most celebrated of them at the commencement of the 18th Century was White's chocolate and coffee house, commonly known as "White's" in St. James street which became the resort of fashionable Londoners. Bontekoë the physician to the Elector Wilhelm von Brandenburg published in 1679 a work entitled "Tractat van Kruyd, Thee, Coffe, Chocolata" in which he spoke very strongly in favour of chocolate and contributed very much to the further extension of its use in Germany. The first chocolate factory in Germany is said to have been erected by Prince Wilhelm von der Lippe about the year 1756 at Steinhude and he brought over Portugese who were specially acquainted with the art.

As to the cultivation of the cacao tree in Mexico, the first information available is that obtained on the invasion of that country by the Spaniards. Prior to that time there is a total absence of anything definite. The tree flourishes best in situations where the mean temperature is between 24° and 28° C. The more distant the place of cultivation is from the equator the less valuable is the produce. The other most essential conditions are long continued moisture of the soil and a soft, loose texture with abundance of humus, above all, shelter from the direct rays of the sun. For those reasons, planters select for their cacao plantations recently broken ground that has not been exhausted by cultivation of other kinds. The plants are either raised in a nursery, until of a suitable age for transplanting, or the seeds are sown on the ground selected for the plantation. The transport of live seeds for new plantations is attended with some difficulties since the seeds very quickly lose their vitality. C. Chalot*) recommends that the vitality of the seeds should be preserved by gathering the fruit shortly before it is perfectly ripe, immersing it in melted paraffin and then wrapping it in paper.

A cacao plantation requires a considerable area, in the proportion of 50 hectares for 20,000 trees. The quantity of fruit to be obtained from that number of trees, as an annual crop, would be worth from £ 1200 to 1300. In planting the seeds, they are set out in rows that are from 8 to 10 m apart, four or five seeds being planted within from 1 to 2 m, the shading trees being planted between the rows. Of each five seeds planted the greater number often fail to germinate, either in consequence of unfavorable weather or as the result of attacks by insects etc.; but if more than one plant grows, the weaker ones are pulled up. Until the plants are two or three years old they are protected by a shed open at one side, and they are transplanted after they have attained a height of about 1 m. The chief enemies of tropical cultivation — weeds, aerial roots, insects, bacterial infection — have to be provided against continually, so as to prevent damage.

Among the diseases to which the cacao tree is liable the one of most importance is that resulting not from the attacks of parasites, but according to L. Mangin,**) from the formation of gum in the wood tissue and bark, which eventually kills the tree. The "cancer" occurring in Ceylon is, according to T. B. Carruthers,***) caused by an Ascomycete fungus burrowing under the bark of the cacao tree. The same authority states that the cacao fruit is attacked by a fungus belonging to the Peronospora (Phytophthora omnivora), it then becomes brown, and yields seed that will not germinate. Excision of the infected parts and then burning them is the remedy to be applied in both cases. In Surinam the cacao beetle deposits its eggs in the bast; the maggots developed from them eat the pith of the tree and thus kill it. In Trinidad one of the worst enemies of the cacao is the fungus Phytophthora omnivora which gives rise to the Cacao Pod disease. Another destructive agent in the Trinidad plantations is a Pyrenomycete Nectria Bainii, Massee. Further damage is done by small beetles, the size of ants (Parasol-ants of Trinidad) which bore through the branches and kill them. Cancerous incrustations (Krüllots) make their appearance at the ends of the branches which die off, and the tree also dies if these diseased growths are not removed.*) Further investigation will no doubt add to the number of diseases to which the cacao tree is subject.

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*) Revue des sciences pures et appliquées 1899. No. 4, page 127.

**) Comptes rend. de l'académie des sciences de Paris 1897. Vol. 124, p. 312.

***) Pharmaceutische Centralhalle 1899. No. 38, p. 585.

Altogether the cultivation of cacao requires constant care. The seed germinates about 14 days after being planted; but flowers are not produced until after 3 or 5 years. After the tree bears fruit it may continue to do so for 50 years. The produce of fruit is largest when the tree is from 12 to 30 years old.

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*) Korrespondenz d. Verbandes Deutscher Schokoladefabrikanten 1899, No. 8.

II. Description of the Cacao tree and its fruits; Collecting the fruit; Fermentation.

The cacao tree, with its abundant red flowers and golden yellow fruit, forms a conspicuous ornament of tropical vegetation. It attains a height of about 8 metres and frequently the trunk is of considerable diameter at the base.

The wood of the cacao tree is porous and light; the bark is cinnamon coloured, the simply alternating leaves are from 30 to 40 cm in length and from 10 to 12 cm broad, seated on a stalk about 3 cm long; the upper surface is bright green and the under surface is of a duller colour, slightly hairy.

The flowers, frequently hairy, occur not only on the thicker branches, but also on the stem, close to the root, singly or united in bunches. Fig. 1.

The formation of fruit takes place only from the flowers of the stem or thicker branches and for 1000 flowers there is only one ripe fruit.

The flowers fig. 2 are very small and their petals are of a reddish white colour.

The calyx is five partite as well as the corolla, the ten filaments are united at their base (fig. 3) and only half of them are developed to fruitful organs (fig. 3 a) which bear the pollen in the four separate anther-compartments.*)

The pistil (fig. 3 c) is formed of five united carpels and bears in each of its five compartments eight ovules (fig. 4).

When young the fruit is green, afterwards becoming yellow and frequently tinged with red; it has the form of an angular cucumber and is of variable size, generally about 25 cm long and 10 cm in diameter.

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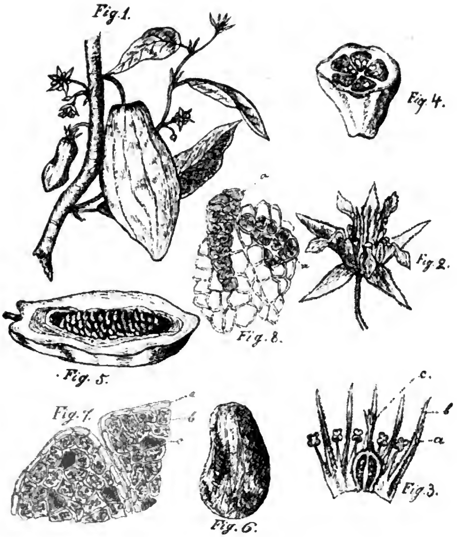
*) Fig. 3b: unproductive filaments.



The fruit fig. 5 has a shell about 15 to 20 mm thick: it is of somewhat softer consistence than the gourd and has five deep longitudinal channels with five others of less depth between them.

The shell encloses a soft sweetish pulp, within which from 25 to 40 almond shaped seeds are ranged in 5 longitudinal rows close to each other. The fruits ripen throughout the whole year though but slowly during the dry season; the time occupied from the commencement of their developement to the time of ripening is about 4 months. The fruit is gathered throughout the year; but the principal gathering is in February and July in Brazil; during March and April in Mexico. Fruit is gathered at all times of the year from the cacao trees growing wild in the forests and it is taken to market by Indians.

The gathering of the fruit is effected by means of a long rod at end of which is a semicircular knife for cutting through the stalk. The fruits are then split in two, the beans separated from the surrounding pulp and spread out on screens to dry gradually upon a bamboo-floor exposed to the sun. The beans after that treatment are generally subjected to fermentation.

In many districts that mode of treating the beans is adopted because it has the effect of improving their flavour. The beans, from which pulp has been separated, are spread out on the ground and exposed to the sun for a day; they are then transferred to wooden troughs, or to large earthen vessels with wide openings, called "tinajás" and after being covered over with leaves they are left for about 24 to 48 hours. Then they are exposed to the sun for from 3 to 5 days and either packed into covered chambers or piled up in heaps and kept at a moderate heat for 4 days or packed in casks and buried in the earth, after either treatment being again exposed to the sun until they are perfectly dried. Aublet described this method of conducting the fermentation process 125 years ago "in his Plantes de la Guiane".

"To preserve the kernel of the cacao, the fruit, when ripe. is cut in halves and the kernels, it contains, are thrown together into a vat. The substance surrounding the kernels ferments within 24 hours, then liquefies and becomes sour. The kernels are left in this liquor until the membranes have become brown and the germ is known to be dead, for the quality of chocolate depends on the maturity of the fruit and on the degree of fermentation it has undergone. The kernels or nibs separate easily from the substance surrounding them and dry by degrees. The sour liquid is acid, but good to drink, and an ardent spirit can be distilled from it, which is highly inflammable and of a nice taste."

In Jamaica the over-ripe beans are fermented in meal casks fitted with perforated bottoms and lined with banana leaves. After the beans have been packed in the casks, they are covered with banana leaves and twigs and then left to ferment for 60 hours. The fermentation goes on with evolution of heat proportionate to the quantity of beans and according to the prevailing condition of weather. A normal progress of fermentation is indicated when the interior of the mass of beans has, on the first morning after gathering, a temperature of 30° to 33° C., on the second day 35° to 38° C. and on the third morning a temperature not exceeding

43° C. If the outer shells are marked with large spots the heating has been too great. As a characteristic of sufficient fermentation the change in the colour of the external layer of the seeds to a clear chocolate brown or brown violet may be relied upon. After the fermentation, it is usual in most plantations to remove the adhering portions of pulp from the beans by washing: then the beans are allowed to dry in the air and they are finally packed into sacks. Contact with metal is to be carefully avoided throughout the whole operation.

The question as to which is the best method of fermentation, that with or that without the presence of the pulp, cannot be determined in the existing state of knowledge of the subject. Nevertheless it is worthy of note that Dr. Chittenden,*) who carefully studied the fermentation process, comes to the same conclusion as Aublet; he describes the state to which the cacao planter has to bring the beans by fermentation in the following manner:

"At this stage, if fermentation has been properly established, the cotyledons are found separated and the vinous liquor of the pulp, which passes through the membranous covering, occupies this space as well as the cavities between the convolutions. This it is which has so marked a physiological influence and affects its flavour, the bean being, as may be said, stewed in its own juice."

The practical result to be reached in the fermentation is, in any case, to convert the colour of the beans, as far as possible, from a harsh red into a chocolate colour or cinnamon brown, as well as to harden the shells or make them tough; also to improve the odour and flavour, besides destroying the fermentating power of the seed. J. H. Hart*) speaking of the fermentation process, makes the following remark, as to the chemical alterations it brings about:

"The results of the examinations and analyses show that the process of fermentation or sweating in cacao, consists in an alcoholic fermentation of the sugars existing in the pulp of the fruit; that process is accompanied by a loss of some of the albuminoid and indeterminate nitrogenous constituents of the beans. Probably the albuminoid constituents are first changed into amides and other simpler combinations which may be further broken up during the process of fermentation. Some parts of the carbohydrates, other than sugars, undergo hydrolysis and either escape in the runnings from the boxes in the form of glucose, or undergo in turn the alcoholic and acetic fermentations."

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*) J. H. Hart, "Cacao", p. 106.

"During this change some of the astringent matters to which the somewhat acrid taste of the fresh bean is due are also hydrolysed and thus a marked improvement in flavour is gained. Small quantities of the mineral constituents, principally of potash and phosphoric acid, are removed from the beans in the liquid escaping from the fermenting material. A slight loss in the woody fibre is shown, which may be due to loss of portions of the cuticle during the operation of drying or to changes in it by hydrolysis during the fermentation."

Axel Preyer*) has recently shown that the fermentation of cacao is brought about by yeast cells and that it is effected by the action of a peculiar ferment fungus Saccharomyces theobroma, Preyer, that is to say the enzyme produced by that fungus causes the chemical alterations which take place in the fermentation of cacao, since that enzyme is enabled by the opening up of the compact tissues of the cotyledons to penetrate into the interior of the parenchyma. The most important chemical alterations which determine the improvement in odour and flavour are probably of a similar nature to those which Kunz-Krause**) considers to be of influence in the treatment of tea. According to that view it may be assumed that, under the influence of the enzyme, aromatophore molecules are produced by the splitting up of organoleptic indifferent aromatogenic groups. Such extra molecular disintegration that is not "intra vitam" is of frequent occurence in plants; in that way the formation of benzoin and Peruvian balsam takes place as well as the change that is known as the ripening of Vanilla pods.

The possible presence of bacteria may be regarded as detrimental to the process of fermentation, since the acid fermentation of mucilage has a bad influence upon flavour. The most favourable conditions for the development of saccharomyces theobroma are afforded by a temperature of 28° to 35° C. when fermentation takes place with access of air and proceeds slowly during a period of from 5 to 6 days. General rules as to the duration of the process cannot well be laid down, since it is influenced still more by other factors, viz. temperature, the kind of cacao and the ripeness of the fruit. Certainly Preyer's observations lead to the conclusion that, in future, the fermentation of cacao may be advantageously controlled by using a ferment artificially cultivated for the purpose.

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*) Der Tropenpflanzer. 1901. V. Jahrg. Nr. 4.

**) Berichte der deutschen chemischen Gesellsch. 1901. Heft 3, p. 154.

The kernel of the fresh bean is white and has a bitter taste; under the influence of solar heat the brown cacao-pigment is formed; but the harsh bitter taste is not destroyed by mere drying to the same extent as by fermentation; hence fermented beans are always preferred.

Commercially and for manufacturing purposes only the seeds of the cacao tree are of importance. The root bark is said by Herr Loher of Manila to be useful in certain female complaints and is employed by the inhabitants of Philippines as an abortifacient. According to Peckolt*) the fruit bark contains a considerable amount of material that yields mucilage, which is not altered by drying and might therefore be employed medicinally as a substitute for linseed.

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*) Berichte der deutschen Pharmaceutischen Gesellschaft 1900. No. 5, p. 115.

III. The Cacao bean.

The varieties of the cacao tree which yield the beans met with at the present time in commerce are

Theobroma bicolor, the seeds of which are mixed with Caracas and Brazilian beans.

Theobroma speciosum, Wildenow, together with Theobroma cacao yield Brazilian beans.

Theobroma guayanense yields Guiana beans.

Theobroma cacao, Linné, the true cacao tree, is most widely distributed and it is the only variety employed in the cultivation.

The varieties:

Theobroma silvestre, forest cacao,

Theobroma subincanum, white-leaved cacao, and

Theobroma microcarpum, smallfruited cacao, are met with as admixtures in Brazilian beans.

Theobroma glaucum, grey cacao; fruits of this variety are found among Caracas beans.

Theobroma augustifolium and

Theobroma ovatifolium may be regarded as characteristic of Mexican cacao.

Before describing the commercial kinds of cacao, a knowledge of which is of first importance to manufacturers, it is desirable to consider the beans in regard to external form and microscopical structure, in order that the use of some indispensable scientific expressions in the subsequent description of particular commercial kinds of cacao may be intelligible.

The cacao bean fig. 6 consists according to Hanausek*) of a seed-shell, a seed-skin and the embryo or kernel with the radicle. The seed is generally from 16 to 28 mm long, 10 to 15 mm broad and from 4 to 7 mm thick. At the lower end of the bean there is a depressed, flattened and frequently circular hilum visible, from which a moderately marked line extends up to the apex of the bean where it forms the centre of radiating longitudinal ribs — vascular bundles — extending to the middle of the bean and through the outer seed-coating back to the hilum.

The outer seed shell is of the thickness of paper, brittle, scaly externally and reddish brown, lined with a colourless translucent dry membrane penetrating, in irregularly divided folds, into the convolutions of the kernel. The shells of some of the better sorts of beans, such as Caracas, are frequently, covered with a firmly adherent, dense, reddish brown powder, consisting of ferruginous loam originating from the soil on which the beans have been dried and serving as a protection against the attack of insects.

The kernels consist of two large cotyledons occupying the whole bean; they are of fatty lustre, reddish grey or brown colour and often present a superficial violet tinge; under gentle pressure the kernel readily breaks up into numerous angular fragments the surfaces of which are generally bounded by the thin seed envelope. At the contact of the lobes there is an angular middle rib and two lateral ribs are connected with the radicle at the broader end of the bean. The ripe fresh-gathered cacao-kernel is undoubtedly white and the reddish brown or violet pigment is formed during the drying of the beans. But there is also a white cacao though it is seldom met with. According to information furnished by Dr. C. Rimbach of Ecuador, it is of rare occurence and is not cultivated to any great extent. In Trinidad also a perfectly white seeded cacao, producing large fruit and fine kernels, was introduced from Central America by the curator of the Botanic Gardens in 1893.

The microscopic structure of the shell presents no remarkable peculiarity that requires to be noticed here.

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*) J. F. Hanausek, Die Nahrungs- und Genussmittel aus dem Pflanzenreiche, p. 437.

The delicate inner membrane (p. 8 fig. 8a) coating the cotyledons and penetrating into their folds consists of several layers. Connected with it are glandular structures fig. 8a, of a club shape, consisting of several dark-coloured cells—that are known as the Mitscherlich-particles. According to A. F. W. Schimper*) they originate from the epidermis of the cotyledon and not, as was formerly supposed, from the inner seed envelope.

These structures, named after their discoverer, were formerly supposed to be algæ, or cells of the embryo sac, unconnected with the tissues of the seed cells. They are however, as true epidermoid structures, similar to the hairs of other plants.

These Mitscherlich-particles are not only characteristic of the seed membrane, but also of the entire seed as well as the preparations made from it. Wherever cacao is mixed with other materials its presence may be ascertained by microscopic examination through the detection of these structures which are peculiar to cacao.

In the large elongated, hexagonal cells of the seed membrane there are two other structures to be seen with the aid of high power (250 fold) one appearing as large crystalline druses, while the other consists of extremely fine needles united in bundles.

By addition of petroleum spirit the former, consisting of fat acid crystals, are dissolved, the latter, remaining unaltered, are considered by Mitscherlich to be theobromine crystals, since their crystalline form closely resembles that of theobromine.

The cotyledons are seen under the microscope to consist of a tissue of thin walled cells, without cavities, lying close together and having here and there distributed through the tissue, cells with brownish yellow, reddish brown or violet coloured contents. These latter are the pigment cells which contain the substance known as cacao-red and analogous to tannin; it, together with theobromine, gives rise to the delicate taste and aroma of cacao. The other cells of the tissue are filled with extremely small starch granules the size of which rarely exceeds 0·005 mm; with them are associated, fat, in the form of spear shaped crystals, and albuminoid substances.

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*) Anleitung z. mikroskopisch. Untersuchung der Nahrungs- und Genussmittel. Jena 1886.

In order to discriminate between these substances they must be stained by various reagents. According to Molisch*) theobromine may be recognised, in sections of the seed, by adding a drop of hydrochloric acid and after some time an equal drop of auric chloride solution (3 %). After some of the liquid has evaporated, bunches of long yellow crystals of theobromine aurochloride make their appearance. On addition of osmic acid the fat is coloured greyish brown. On adding to the microscopic section a drop of iodine solution the starch becomes blue**) while albuminous substances are coloured yellow. Cacao starch granules are very small and cannot well be mistaken for other kinds, except the starch of some spices such as pimento or that of Guarana, prepared from the seeds of Paullinia sorbilis. According to Möller the blue iodine coloration of cacao starch takes place very slowly and it is probably retarded by the large amount of fat present.***)

In order to make the starch granules of cacao and the cells containing cacao-red distinctly visible under the microscope it is advisable to immerse the section in a drop of almond oil, because the addition of water renders the object indistinct in consequence of the large amount of fat present. Another excellent medium for the microscopic observation of cacao is the solution of 8 parts of chloral hydrate in 5 parts of water recommended by Schimper.

By these means it may easily be seen that the pigment or cacao-red in different sorts of cacao varies more or less in colour.

To complete the account of the microscopic characters of the cacao cotyledon, mention must be made of the small vasculàr bundles, generally spiral, that are distributed throughout the tissues of the cotyledons and are readily made visible by adding a drop of oil or a drop of chloral hydrate solution.

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*) Grundriss einer Histochemie der pflanzlichen Genussmittel. Jena 1891, p. 23.

**) The action of iodozinc chloride is more expedient.

***) I have always noticed the re-action at once.

IV. Commercial sorts of Cacao beans.

The various sorts of cacao met with in commerce are named according to the countries where they are grown or the ports from which they are shipped. Though there are, in that respect, many kinds of cacao, they may be classified under a few heads since the produce of small districts is more or less mixed in the large warehouses.

The cacao beans grown in the several localities are, in general, much alike in so far as conditions of soil, temperature and treatment are the same. The great differences in price formerly prevailing, according to the quality of the article, are now considerably equalised though in a few instances they are still of some importance. Thus for instance, Trinidad and Caracas cacao was sold in 1894 in the London market at nearly the same price viz. 66 to 82 shillings the hundredweight, while Granada and St. Domingo fetched only 56 or 62 shillings, Surinam and Guayaquil about 61 to 71 shillings and the finer sorts of Ceylon realised 75 to 89 shillings.

In describing the external characters of different commercial sorts of cacao it must be remembered that there may be considerable differences in the cacao imported from a particular source and that, while competition between the means of transport has also some influence, the growers of cacao are everywhere endeavouring to improve the treatment of it so as to produce a good marketable commodity. The effect of those conditions is to do away with any obvious distinctions. One of the most essential factors to be considered in judging of commercial sorts of cacao, is the more or less favourable conditions under which the beans are gathered. That may vary considerably if the gathering is carried out during bad weather or it is interfered with by the prevalence of political disturbances. The colour of particular commercial sorts may, for instance, be much affected and present differences even in the same parcel. Moreover, cacao from different sources may be mixed in the course of European trade and, for those reasons, only general characteristics can be relied upon as being in some degree typical.

In enumerating the different commercial sorts of cacao the chief point to be considered is the geographical source. The classification as "unfermented" and "fermented" cannot well be adhered to at the present time. Thus for instance, Brazilian cacao which was formerly unfermented, is now for the most part fermented and very carefully prepared, so that the produce of plantations in the Amazon district is now scarcely inferior in quality to the best commercial sorts imported from the northern states of South America.

American Cacao.

Venezuelan and Ecuador Cacao.

The beans from these two districts have always taken a prominent position in the market. The finer sorts are never exported to Europe, since they are cultivated only to a small extent and are, for the most part, consumed in the country. The kinds that are distinguished are:

1. Soconusco from the Province of Venezuela. The beans are small, very plump, and markedly convex. The shell is bright and of a pale yellow colour. The taste is free from acridity, mild and fatty. These beans are sometimes found to have an admixture of the beans of Theobroma augustifolium and those of T. ovatifolium.
2. Esmeraldas, from the Republic of Ecuador. These beans are rather smaller, plumper, and darker coloured than the Soconusco, and they are very heavy.

The chocolate made from these two sorts retains the colour of the beans and is considered to be the choicest.

Among the commercial sorts imported from Venezuela the first place is occupied by

The cacao of Caracas.

This is employed in the manufacture of the finest qualities of chocolate consumed in Europe, and is exported in large quantity. It is met with as small and large beans. In both sorts the shell is coated with a reddish brown earthy crust. The smaller beans contains rather less fat than the larger ones, and for that reason they are cheaper. The Caracas beans have frequently some admixture of seeds of Theobroma bicolor (Humboldt.). According to market value Caracas cacao is classified as 1. Chuao; 2. Ocunnare; 3. Choroni; 4. Puerto cabello; 5. Guiria; 6. Carupano; 7. Rio Caribe; 8. La Guayra or Rio Chico; these being the names under which Caracas cacao is sold in the French market. The other peculiarities of Caracas beans are

Beans: markedly convex.

Cotyledons: externally reddish brown, internally red brown.

Mean size: 23 mm long, 15 mm broad, 8 mm thick.

20 beans weigh 35,5 grammes.

Microscopic appearance under oil: the pigment cells (cacao red) are numerous, generally pale brown, rarely with a violet tinge passing into blue.

Cacao from Puerto Cabello.

Two kinds of beans are met with in commerce under this name; the one is large.

Beans: large, thick, ovoid, but slightly flattened.

Shell: coated with an ochreyellow earthy crust.

Cotyledons: externally reddish brown internally also red brown.

Mean size: 24 mm long, 15 mm broad, 8 mm thick.

20 beans weigh 25 grammes.

Microscopic appearance under oil: pigment cells very large and numerous, clear violet-red coloured and transparent. Taste mild.

The other kind is more astringent in taste and has probably been gathered when less ripe, it is therefore of less value. The other characters are like those above stated. Puerto Cabello beans are chiefly consumed in France and Spain.

Among the sorts of cacao from Ecuador are the well known Esmeraldas.

a) Ariba Guayaquil.

The finer sorts, as well as b, are mostly used to mix with other sorts for making the better qualities of chocolate.

Beans: very large, flat, triangular, and of irregular shape.

Shell: pale yellow brown with earthy coating.

Cotyledons: deeper coloured externally than internally.

Taste: slightly bitter.

Mean size: 24 mm long, 15 mm broad, 6 mm thick.

Microscopic appearance under oil: pigment cells abundant of a dark violet colour and frequently several of them adjoining.

20 beans weigh from 34 to 35 grammes.

b) Machala Guayaquil.

This is one of the kinds richest in fat.

Beans: flat, of irregular shape, with dirty brown coloured shell.

Cotyledons: externally dark brown, paler internally.

Taste: bitter.

Mean size: 22 mm long, 13 mm broad, 5 mm thick.

20 beans weigh 23,5 grammes.

Microscopic appearance under oil: the layers of cells at the edge of the cotyledons are mostly brown; the interior cotyledon tissue has fewer pigment cells and they are often violet coloured, seldom brown.

Guayaquil cacao is chiefly consumed in Germany. The total production is very large, amounting in 1893 for Ariba to 293,284,000 kilos, for Balao and Naranjal to 39,923 and for Machala to 68,925,000 kilos. The total export for the same year amounted to 18,529,729 kilos of the value of 9,765,529 sucres.*)

Cacao of Surinam.

From Dutch Guaiana.

There are two varieties of this cacao:

1. That grown on plantations; a riper and finer sort.
2. That growing in the forest, generally from unripe fruit and badly dried.

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*) One Sucre of 100 centavos = about 4 shillings.

The taste of the latter kind is more bitter and rancid; it is but rarely met with in Germany and is, for the most part, consumed in Holland. The total production of cacao in Surinam was in 1899 32,000 bales.

Beans: large and dense.

Shell: greyish brown, owing to a coating of greyish loam.

Cotyledons: dark red brown.

Mean size: 20 mm long, 12 mm broad, 6 mm thick.

Taste: acrid bitter.

20 beans weigh 33 grammes.

Microscopic appearance under oil: the pigment cells are not well defined, yellowish to orange coloured, seldom violet. Outside, the pigment penetrates into the cells so frequently that they appear brown or yellowish brown.

Among the less important commercial sorts of cacao are:

Maracaibo (Columbia, Province of Culia).

This cacao is but little inferior to the Caracas cacao and it is often mixed with the latter. The cultivation of cacao in Maracaibo is not very extensive, and this sort is not very often met with in commerce.

Beans: of medium size with smooth reddish brown dusty surface.

Cotyledons: reddish brown or ochre coloured and generally resembling Caracas cacao in appearance and weight.

Berbice cacao (British Guiana).

Beans: small, externally grey, internally reddish brown, closely resembling Surinam but smaller, very rich in fat and very brittle; when pressed between the fingers the shell is easily detached.

Essequibo cacao (British Guiana).

Beans: large, solid, internally dark reddish brown. Taste: bitter. These beans are frequently mixed with Surinam cacao which they closely resemble.

Angostura and Pedraza are distinct kinds of Columbian cacao which are similar to that of Guayaquil.

Brazilian Cacao.

a) Cacao Marañon.

The beans of this mark are small, elongated, slightly flattened, almost straight at one edge and strongly convex at the other. The colour of the cotyledons is dark red; these beans are very rich in fat. Marañon as well as Parâ cacao (Amazon) is very highly esteemed when it is unmixed, which is very rarely the case, the latter kind having especially admixtures of beans of Theobroma speciosum, T. subincanum and T. silvestre. Both kinds have a bitter taste.

The cotyledons are hard and friable.

b) Cacao de Bahia is the chief representative of Brazilian cacao. The better kinds of it have been fermented, the inferior kinds are brought to market unfermented.

Beans: flat, triangular, bulging at the edges.

Shell: in the fermented kinds cinnamon brown, in the unfermented kinds dirty grey with an earthy coating.

The cotyledons are externally black, internally from blackish brown to violet with many pigment cells and lumps of fat.

Mean size: 23 mm long, 14 mm broad, 4 mm thick.

20 beans weigh 24 grammes.

It is a remarkable circumstance that the use of cacao was unknown to the natives of Brazil prior to the advent of Europeans.

Cacao of Cayenne (French Guiana) is of inferior quality and is rarely met with in commerce; the beans are hard, externally greyish brown, internally violet, and the taste is very astringent. The best sort, "Oyaback", has bright red beans.

Cuban Cacao.

This cacao was regulary imported ten years ago, according to P. J. Stollwerck, and it was of excellent quality. But since it did not command so good a price in England, Germany or France as in Spain, it has since that time been sent to Spain only. At present it is again appearing in the market but is not so good as formerly, perhaps in consequence of the cultivation being interfered with by the war in recent years.

Beans of very unequal size, almost always flat, of poor appearance and irregular form.

Shell: firmly adherent to the kernel and partly covered with dried fruit pulp.

Cotyledons: of a dark violet brown colour.

20 beans weigh 21,5 grammes.

Taste: agreeably bitter.

Microscopic appearance under oil: pigment cells coloured for the most part a fine violet red and clustered together in longitudinal rows.

Varieties of cacao from the West Indies.

Haiti or Port au Prince. The beans are on the average rather smaller than those of the mainland and of inferior quality.

Beans: flat, eggshaped; they are much used for mixing with those from the mainland to produce an inferior article.

Shell: bright brown.

Cotyledons: uniformly blackish brown.

Taste: slightly bitter.

Mean size: 23 mm long, 14 mm broad, 4 mm thick.

20 beans weigh 25,8 grammes.

Microscopic appearance under oil: numerous large and small pigment cells distributed through the tissue, the former dark violet, the latter reddish violet and yellowish brown.

Trinidad cacao. The cacao grown in Trinidad is, together with that grown in Ceylon, of most importance in connection with the manufacture of chocolate in England. Three varieties are grown which are called Calabacillo, Criollo, and Forastero. The first two varieties are less in quantity than the last named, and the total produce of the island amounted according to J. Hinchley Hart, in 1900 to about 20,000,000 pounds.

Beans: very large, broad and flat.

Cotyledons: internally blackish brown.

Shell: yellowish brown, readily detached.

Mean size: 25 mm long, 18 mm broad, 4 mm thick.

Microscopic appearance under oil: the tissue of the cotyledons is externally of a dirty grey brown extending inwards. The pigment cells are yellowish brown and frequently violet.

St. Domingo cacao:

Beans: very flat, of irregular shape.

Shell: red brown.

Cotyledons: externally blackish blue, internally of paler colour.

Taste: bitterish.

Mean size: 22 mm long, 13 mm broad, 4 mm thick.

20 beans weigh 25,5 grammes.

Varieties of less frequent occurrence are Guatemala, very much prized and considered equal to Caracas cacao, Martinique rather inferior and used chiefly for mixing with better kinds.

Asiatic Cacao.

The most important of the sorts of cacao cultivated in Asia is the cacao of Ceylon. It is exported only from December to May, from Colombo, in sacks weighing 1¼ cwt. Almost all the Ceylon cacao goes to the London market and is thence transfered to the countries where it is consumed, principally to North America. Small quantities are sent direct to France, Germany, North America and Manila.

The characteristics of the fine Ceylon beans are:

Beans: oval and only slightly flattened.

Shell: very thin, reddish brown, readily detached. Vascular bundles distinctly visible.

Cotyledons: externally a fine red brown, internally much paler, the section is frequently whitish especially near the periphery of the seed lobes, very friable.

Mean size: from 18 to 22 mm long, 12 mm broad, 7 mm thick.

20 beans weigh 20 grammes.

Taste: agreeably bitter.

Microscopic appearance under oil: scanty pigment cells of a bright brown colour.

In addition to the finer qualities of Ceylon cacao, which generally command a high price, there are inferior sorts met with in commerce. They are mixtures of large and small beans. The shell is brown or dirty greyish brown. The taste is good, but the cotyledons are much more compact and denser than that of the better kinds. The cheapest and most inferior kind of Ceylon cacao is known by the name of "native Ceylon". Its colour is much inferior to that of the other kinds, it has scarcely any taste and frequently it has a tallowy smell which renders it entirely inapplicable for the manufacture of chocolate.

Java cacao.

Cacao was planted in Java in 1830 and from the year 1850 the cultivation has been carried on through the aid of the Botanic Garden at Buitenzorg. In recent years the export of cacao has increased enormously and the produce fetches a high price in the European market. Java cacao is chiefly imported into Amsterdam, and in 1899 the quantity offered for sale there amounted to 15,247 pikuls.*)

Beans: generally similar to the Ceylon cacao but rather rounder, the upper end being somewhat pointed, the lower end broad.

Shell: readily detached, very thin, abundantly fissured, of a bright brown colour varying to dark brown.

Cotyledons: generally of a bright red brown colour.

Mean size: 23 mm long, 12 mm broad, 9 mm thick.

20 beans weigh 16,5 grammes.

Taste: agreeably bitter.

Microscopic appearance under oil: scanty pale brown pigment cells.

African Cacao.

The African cacao of most importance at the present time are Cameroon and St. Thomé cacao.

Cameroon cacao.

The cultivation of which is carried on chiefly at the stations of Bibundi, Victoria and Buea where it flourishes excellently well. In the short space of time between 1889 and 1896 the export of cacao has risen from 5 sacks to 3320 sacks, and there is every prospect that it will soon be double as much. The Cameroon cacao requires however many years of cultivation before it will be equal in flavour and aroma to the American cacao. As a marketable article, at present it can only serve as a substitute for mixing with better kinds in the proportion of from 6 to 8 per cent as the utmost that is admissable in order to produce good chocolate.

Beans: presentable, generally flattened.

Shell: bright cinnamon brown, moderately thick, sometimes difficult to detach from the kernel.

Cotyledons: of a fine dark violet colour.

Mean size: 21 mm long, 16 mm broad 7—8 mm thick.

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*) picul = 61 kilos.

20 beans weigh 23,5 grammes.

Taste: rough and coarse.

Microscopic appearance under oil: numerous greyish brown and violet pigment cells.

In addition to the Cameroon cacao, Africa yields the short Bourbon cacao bean that is chiefly used for mixing with better kinds, also the cacao of St. Thomé, Principe and Fernando Po. The cultivation in all those districts is being rapidly developed. The produce of St. Thomé has a very special interest for European trade and for the manufacture of chocolate in England, since the quantity exported in the course of the last 25 years (1869—1895) has increased from 50,867 kilos to 5,670,000 kilos. The chief characteristics of the St. Thomé cacao beans are that they are generally flattened, more convex on one side than on the other; the shell is brownish black and readily detached; the cotyledon tissue is of a dark brown colour, odour and taste tolerably good. This cacao is therefore much used for mixing; the price at the Hamburg market in 1899 varied from 60 to 68 shillings for 50 kilos. In Eastern-Africa the German East-African agricultural Company is endeavouring to open up its vast possessions for the cultivation of cacao and it may be expected that, at no very distant period, African cacao will come into competition with the most esteemed brands of American and Asiatic cacao.

V. The trade in cacao and the consumption of cacao products.

Though cacao has always been held in high esteem, since it became known in Europe, it was long before its use became general among all classes, on account of its comparatively high price. But the remarkable increase that has taken place in the facilities of transport during the latter half of the past century, has afforded unexpected opportunities for the importation of exotic produce. The influence of those conditions has been advantageous in the case of cacao by bringing about increased supply and demand. The effect is apparent not only in constantly increasing importation of cacao but also in progressive extension of its cultivation and in the corresponding reduction in the price of the raw material. As a further consequence, cacao preparations have become cheap and capable of being used by the people generally. The extensive use of these preparations has also helped to reduce the evils of intemperance and, in the best sense of the term, to provide a useful article of diet. The extraordinarily rapid increase in the production of cacao and in the trade in that commodity may best be shown by the statistics relating to the importation of cacao into France. In 1857 the quantity imported into that country was 5,304,207 kilos of which 3,412,929 kilos was consumed in the country. But in the following years the quantity was considerably greater as shown below.

	kilogrammes
1886	18,603,409
1891	24,338,121
1896	28,392,265
1897	24,977,193

Of the cacao imported into France in 1897, the quantity brought from foreign countries was 24,088,560 kilos, and 888,633 kilos came from French Colonies. On the other hand France exported in 1897 to

	kilogrammes
England	1,700,435
Germany	4,349.798
Holland	3,190,920
Belgium	974,985
Switzerland	1,875,118
Other Countries	629,945
French Colonies	1,925
Total	12,723,126

The cacao imported into France came chiefly from Venezuela, the British West Indies, Brazil, Ecuador, Hayti and Columbia.

Similar satisfactory prospects present themselves for German trade, for the German Colonies and for the consumption of cacao in Germany. Official returns show that the trade there in cacao preparations is very extensive.

Year of import	Raw beans 100 kilog.	Value 1000 marks	Chocolate and chocolate preparations — since 1895 chocolate substitutes — 100 kilog.	Value 1000 marks	Powder cacao and cacao mass — since 1895 cacao husk and up to 1895 chocolate substitutes — 100 kilog.	Value 1000 marks	Cacao butter 100 kilog.	Value 1000 marks
			a) Imports					
1892	73,305	10,703	1,852	500	5,503	1,649	1,464	322
1894	92,605	10,324	1,733	468	5,565	1.481	1.630	399
1896	134.591	13.384	1.784	428	6.573	2,339	95	23
1898	147,144	21.439	2.546	611	6.558	2,354	1.574	315
1899	189,965	25,805	2.892	687	7.121	2,551	276	75
			b) Exports					
1892	254	39	4,387	768	547	160	207	50
1895	1,228	136	7,589	1,176	2,868	650	557	136
1896	1,464	146	6,711	1,020	2,659	598	2.839	696
1898	1,676	345	18,914	1,872	3,627	894	1.733	360

These figures taken from the publications of the Society of German Chocolate makers Vol. XIX plainly tell their own story. They show that the importation of cacao into Germany has been more than doubled since 1892. At the same time very large quantities of manufactured cacao products were imported into Germany, about one half of the imports coming from Switzerland, another fourth from France, while cacao powder was almost exclusively imported from Holland.

There was also a constant increase in the export of German cacao products, showing that they were good and marketable. The exports went chiefly to North America and to Great Britain. The import of cacao butter, which had almost ceased in consequence of the imposition of duty in 1895, has within the last few years, risen again since the stock on hand had been consumed and an extra supply of that material is required for the manufacture of chocolate creams, pralinés etc. The export of cacao butter from Germany has also increased considerably, and it is likely to increase still further in view of the drawback that is allowed.

In England, the consumption of cacao products has increased during the last 20 years nearly four fold. In 1874 the consumption in the United Kingdom amounted to 8,300,000 pounds, and in 1894 it was estimated at more than 22 million pounds. In 1895 the English cacao factories sold 24,484,502 pounds of cacao preparations and 20/24 of the cacao they consumed was grown in the British Colonies. Holland also consumes very large quantities of cacao; at the present time about 30 factories, large and small, work up annually 13 000 tons of the raw material.

According to H. Jumelle*) the consumption of cacao in Europe may be estimated at upwards of sixty-five million kilos; of that quantity 16 million kilos are consumed in France, 20 million kilos in Germany, 12 million kilos in England, 10 million kilos in Spain and 1 million kilos in Russia. The consumption of cacao preparations per head of the population in various countries is given by the "Grocer" and by the "Institut international de statistique" as follows for the year 1889

Spain	403	grammes
France	312	,,
England	155	,,
Denmark	122	,,
Germany	57	,,
Norway	53	,,
Sweden	22	,,
Austria	10	,,

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*) Le Cacaoyer, Paris 1900. p. 53.

These figures have however been subject to much alteration since the time to which they apply.

The amount of capital employed in the cacao trade throughout the world may be seen from the following statements.

In the years 1894 to 1895 the value of the raw cacao imported into the United States of America amounted to 4,017.801 dollars which is about the value of the importation into Germany in those years. But the value of the imports for the year 1893—94 was only 2,402,382 dollars while in the year 1892—93 it amounted to 3,195,811 dollars.

The importation of raw cacao into France amounted in 1893 to 28·2 million francs, in 1894 to 24·8 million francs or about 50 percent more than the German imports; in the same year the export of raw cacao was of the value of half a million francs.

In 1897 the value of the raw cacao imported into France was 39,214,193 francs. The value of the cacao products consumed in France was 25,457,468 francs; to that is to be added import duty, amounting to 16,336,038 francs. But the value of the exported products was 19,975,308 francs.

The imports of raw cacao into Great Britain in 1894 amounted in value to 1,255,201 pounds sterling and perhaps one fifth of the quantity was again exported, so that the value of the English imports was almost equal to the French.

Within recent years the relative consumption of coffee, tea and cacao has undergone a change in favour of cacao. According to a statement in the publication of the Association of German Chocolate makers (Vol. XIX, No. 7) the imports into Germany were as follow.

Year	Coffee raw beans	Cacao raw beans 100 Kilos	Tea
1886	1,236,305	36,867	16,185
1887	1,018,334	42,950	17,600
1888	1,146,581	49,798	17,784
1889	1,132,285	55,651	18,750
1890	1,181,263	62,465	19,950
1891	1,256,112	70,870	22,210
1892	1,220,310	74,000	24,790

Year	Coffee raw beans	Cacao raw beans	Tea
		100 Kilos	
1893	1,221,905	79,609	26,760
1894	1,223,575	83.199	28.400
1895	1,223,902	90.509	25.440
1896	1,298.966	122.095	24.710
1897	1.363,950	146,925	28,520
1898	1.532.704	154.649	36,619

According to these data the consumption of cacao products has steadily increased. Within the period referred to, the import of coffee increased only 24 percent, that of tea 125 percent while that of cacao has increased 330 percent. Comparing the quantities of coffee, cacao and tea for the years 1886 and 1898 they were as follow.

	1886	1898
Coffee	96·0 percent	89·0 percent
Cacao	2·8 „	8·9 „
Tea	1·2 „	2·1 „
	100·0 percent	100·0 percent

So that while in 1886 the quantity of coffee imported was 35 times that of the cacao imported, the import of coffee, in 1898, was only ten times as much as that of cacao.

The consumption of these three articles in Germany has naturally increased in the same proportions as the imports. According to information furnished by the statistical department, the consumption of tea during the period 1861—65 amounted to 0·02 kilo per head annually, that of cacao to 0·03 kilo, and that of coffee to 1·87 kilo; in the year 1897 the relative consumption amounted to 0·05 kilo tea. 0·27 kilo cacao and 2·52 kilos coffee.

VI. The Chemical Constituents of the cacao bean.

Inasmuch as the beans of the cacao fruit, as already stated, are botanically regarded as the seed, so likewise are their chemical constituents to a great extent the same as those of other seeds. They consist of the substances commonly known as reserve materials which are furnished to the seed by the mother plant in order that the young plant may feed upon them until its organs are sufficiently developed for independent existence. In addition to the usual plant constituents such as albumin, starch, water, fat, sugar, cellulose and ash, the cacao bean contains two peculiar substances, namely, theobromine and cacao-red.

The following table of chemical analyses shows the proportions of all these ingredients in the seed and includes the results obtained by the older authorities, since their work has served as the basis of later investigations.

Percentage composition of the decorticated bean.

Analyst	Payen 1)	Lampadius 1)	Mitscherlich 1)	
Constituents per cent	Undescribed	West Indies	Guayaquil	Caracas
Water	10·0	3·40	5·60	—
Nitrogenous matter	20·0	16·70	14·39	—
Theobromine	2·2	—	1·20	—
Fat	52·0	53·10	45—49	46—49
Cacao-red	—	2·07	3·50	—
Sugar	—	—	0·60	—
Gum and starch	10·0	7·75	14·30	13·5
Woody fibre	2·0	0·90	5·80	—
Ash	4·0	3·43	3·50	—

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1) Mitscherlich, page 57.

Constituents per cent	Laube & Aldendorff.					C. Heisch.			
	Caracas	Guayaquil	Trinidad	Puerto Cabello	Surinam	Granada	Bahia	Cuba	Pará
Water	4·04	3·63	2·81	2·96	3·76	3·90	4·40	3·72	3·96
Nitrogenous matter	14·68	14·68	15·06	15·03	11·00	12·45	7·31	8·56	12·50
Fat	46·18	49·04	48·32	50·57	54·40	45·60	50·30	45·30	54·30
Starch	12·74	11·56	14·91	12·94	—	—	—	—	—
Other non nitrogenous matter .	18·50	12·64	12·06	11·49	28·35	35·70	35·30	39·41	26·33
Woody fibre . .	4·20	4·13	3·62	3·07	—	—	—	—	—
Ash	3·86	3·72	3·22	3·94	2·35	2·40	2·60	5·90	3·06

Analysis made by the author in 1886 gave the following results*):

A. Analysis of the raw shelled bean (kernel).

Constituents per cent	Ariba	Machala Guayaquil	Caracas	Puerto Cabello	Surinam	Trinidad	Port au Prince	Average
Moisture	8·35	6·33	6·50	8·40	7·07	6·20	6·94	7·11
Fat	50·39	52·68	50·31	53·01	50·86	51·57	53·66	51·78
Cacao - tannic acid, sugar, decomposition products, phlobaphen	8·91	13·72	10·76	7·85	8·31	9·46	11·39	10·02
Theobromine . . .	0·35	0·33	0·77	0·54	0·50	0·40	0·32	0·45
Starch	5·78	8·29	7·65	10·05	6·41	11·07	8·96	8·33
Cellulose and proteïn	22·10	14·45	19·84	15·83	24·13	18·43	15·81	18·71
Ratio of proteïn to cellulose	7·3 : 1	5 : 1	6·6 : 1	5·3 : 1	8 : 1	6 : 1	5·25 : 1	6·2 : 1
Ash	4·12	4·11	4·17	4·32	2·72	2·87	2·92	3·60

(See table B, p. 34.)

Ridenour*) has lately published a series of analyses of raw and roasted cacao beans, which are given in detail. At the same time I am in accord with Filsinger,*) that the results stated are not free from objection as representing normal beans since the amounts of fat, starch, albumin and ash differ so essentially from results hitherto obtained.

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*) Investigations of cacao and its preparations, page 56 and 57.

**) Ridenour, American Journal of Pharmacy 1895, Vol. 67, page 202.

***) Filsinger, Chemiker Zeitung 1887 p. 202.

B. Analysis of the roasted shelled bean (kernel).

Constituents per cent	Commercial kinds							
	Ariba	Machala Guayaquil	Caracas	Puerto Cabello	Surinam	Trinidad	Port au Prince	Average
Moisture	8·52	6·25	7·48	6·58	4·04	7·85	6·27	6·71
Fat	50·07	52·09	49·24	48·40	49·88	48·14	46·90	49·24
Cacao - tannic acid, sugar and phlobaphene	8·61	7·84	6·85	8·25	8·08	7·69	7·19	7·78
Theobromine . . .	0·30	0·31	0·5	0·52	0·54	0·42	0·36	0·43
Starch	9·10	11·59	9·85	10·96	10·19	8·72	12·64	10·43
Cellulose and proteïn bodies	19·43	18·17	22·16	21·21	24·39	23·06	21·82	21·43
Ratio of proteïn to cellulose . . .	6·5 : 1	6 : 1	7·7 : 1	7 : 1	8 : 1	7·6 : 1	7·3 : 1	7·1 : 1
Ash	3·89	3·75	3·92	4·08	2·88	4·12	4·82	3·92

Ridenour:	Commercial kinds						
Constituents per cent	Bahia	Surinam	Java	Trinidad	Roasted Trinidad	Ariba	Caracas
Fat	42·10	41·03	45·50	43·66	41·89	43·31	36·81
Theobromine	1·08	0·93	1·16	0·85	0·93	0·86	1·13
Albumin	7·50	10·54	9·25	11·90	12·02	10·14	10·59
Glucose	1·07	1·27	1·23	1·38	1·48	0·42	2·76
Saccharose	0·51	0·35	0·51	0·32	0·28	1·58	1·56
Starch	7·53	3·61	5·17	4·98	5·70	6·37	3·81
Lignin	7·86	3·90	6·10	5·65	5·87	4·62	3·28
Cellulose	13·80	16·24	13·85	13·01	19·64	14·07	16·35
Extractive by difference	8·99	13·53	8·90	8·31	5·84	9·00	12·72
Moisture	5·96	5·55	5·12	6·34	2·63	5·90	6·63
Ash	3·60	3·05	3·31	3·60	3·70	8·73	4·36

Ridenour:	Commercial kinds					
Constituents per cent	Roasted Caracas	Granada	Tabasco	Machala	Maracaibo	Average
Fat	37·63	44·11	50·95	46·84	42·20	42·99
Theobromine	0·99	0·75	1·15	0·76	1·03	0·97
Albumin	12·36	9·76	7·85	12·69	11·56	10·51
Glucose	1·76	1·81	0·94	1·60	1·09	1·46
Saccharose	0·51	0·55	2·72	0·46	1·36	0·89
Starch	6·07	6·27	3·51	1·35	1·69	4·67
Lignin	9·05	5·55	6·44	5·95	7·16	5·95
Cellulose	11·69	13·49	12·57	11·32	17·32	14·44
Extractive by difference	9·22	9·72	9·26	9·02	6·79	9·30
Moisture	5·69	5·28	1·55	5·86	5·67	5·18
Ash	5·03	2·71	3·06	5·15	4·13	3·70

Having given in the previous tables the chemical constituents of the cacao bean, the properties of the constituents may now be considered more closely, as an acquaintance with their chemical and physical properties will on the one hand show how to avoid loss in the manufacture and at the same time make intelligible certain parts of the operation.

As already stated the following substances occur in the cacao bean in varying amounts:

1. Water.
2. Starch.
3. Albumin.
4. Cacao-red.
5. Theobromine.
6. Fat.
7. Grape and cane sugar in small quantity.
8. Fibre.
9. Mineral or ash constituents.

The cacao bean consists, like the majority of plants and parts of plants, of a number of layers of vessels or cells. The membrane of these cells is composed of cell fibre or cellulose. The contents of the cells consist of fat, albumin, moisture, starch, theobromine, cacao-pigment as well as a small quantity of sugar and salts.

1. The water or moisture.

The bean contains from 6 to 8 percent of water. The analytical determination is carried out by placing a weighed portion of the finely powdered bean in a drying oven at 105° C. The substance in a thin layer is kept for some hours at that temperature and then quickly placed under a desiccator to cool so as to avoid re-absorption of moisture. The desiccator consists of a dish containing a desiccating substance, such as calcium chloride or sulphuric acid, and is covered with a bell jar. The substance is allowed to stand under the desiccator for two hours, then weighed and the loss in weight is calculated as water.

2. The fat.

Fat is one of the most important reserve materials of the plant, as respiration is produced chiefly at its expense; it is found deposited in many seeds in large quantity. When seen under the microscope it appears either as round coherent masses or as crystalline aggregates which are well distinguishable from the rest of the cell contents by means of a solution of osmic acid. The fat in the cacao bean usually amounts to 50—56 percent or about one half of the total weight of the shelled bean; the shell also contains from 4 to 5 percent of fat.*) The unfermented bean frequently has, in addition to its bitter taste, a rancid flavour, which is due to the rancidity of the fat.

The fat can be extracted in two ways. On a manufacturing scale it is usually obtained by hot pressure by means of an hydraulic press although, in that manner, the whole of the fat is never extracted. This however can be accomplished by an analytical method, which consists in treating the finely ground bean with a solvent until all the fat is removed. In this operation 5 grammes of the very fine powder should be mixed with an equal quantity of quartz sand in a warm mortar then extracted during 10 to 12 hours with petroleum ether (boiling point under 50° C.) in a Soxhlet's tube. The petroleum ether is evaporated off on the water bath from the weighed flask and the fat residue dried for two hours in the water oven, then allowed to stand under the desiccator for two hours to cool before weighing. The increase in the weight of the flask is the ether extract which consists almost exclusively of fat. Other solvents of fat can be employed, such as ether, chloroform, carbon bisulphide etc. but these are not to be recommended as they dissolve more of the theobromine than petroleum ether. When only the fat determination is required without regard to the other constituents, such as theobromine, starch etc., it is more convenient to extract the fat with ether than with petroleum ether. The raw bean generally contains rather more fat than the roasted bean, the former averages 50—55 percent whilst the latter does not contain more than from 48 to 52 percent. That may be due to enrichment of the husks in fat, and, in the case of over roasting the beans, it may be the result of burning the fat, which would cause a chemical alteration of the fatty bodies (formation of acrolein).

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*) The husks contain no fat when in a fresh condition but absorb fat from the bean when the cacao is fermented, dried and roasted, mostly in the latter case when a great loss of moisture takes place.

Cacao fat is chemically constituted of a mixture of glycerides of fatty acids and contains in addition to stearin, palmitin and laurin, the glyceride of arachidic acid. Cacao butter was also believed to contain formic, acetic and butyric acids but this view is controverted by Lewkowitsch.*) The theobromic acid alleged to have been found by Kingzett**) has also been called into question by Graf.***)

Cacao fat is a yellowish white and fairly firm fat which acquires a yellowish colour on long keeping and has a peculiar taste and smell. When freshly pressed it has frequently a brownish shade passing after a short time into a fine yellow and finally becoming almost white. The brown shade of the freshly expressed fat is due to a suspended pigment which sinks to the bottom when the fat is melted and the butter then acquires the normal colour. The latter is not due to a suspended but to a dissolved pigment, to some extent produced in roasting, the effect of which is to give the peculiar taste and smell to the cacao butter. The fat extracted by solvents differs essentially from that obtained by hydraulic pressure, it is yellowish white to grey, and by keeping, quickly becomes white from the outside to the interior, which is a sign of rancidity; its fracture is partly granular, it has less smell than the expressed fat; its flavour is sometimes unpleasant and the taste often acrid. The keeping properties of cacao butter, contrary to the usual opinion, are not essentially better than those of other vegetable fats. Cacao fat according to Lewkowitsch†) can become rancid. Rancidity in fatty substances is shown by offensive smell and taste which become apparent after a longer or shorter time, especially when the fat is improperly kept. The chemical change which then takes place has not yet been satisfactorily ascertained. From the experiments of Lewkowitsch††) and others†††) it is shown that the rancidity of fat is not due to the formation of fatty acids, although a marked increase in amount may occur, but the explanation may more probably be found in the oxydation products of glycerine, such as aldehyde and ketone bodies.

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*) Journ. of the Soc. of Chem. Industry 1899, p. 566.

**) Chevalier and Baudrimont, Dictionnaire des altérations p. 195.

***) Archiv für Pharmacie 1888. Vol. 26. p. 830.

†) See previous reference.

††) See previous reference.

†††) Schmidt, Zeitschrift f. analyt. Chem. 1898. Vol. 37. pag. 301 and P. Welmans, Pharmaceutische Zeitung 1894, p. 776.

The specific gravity of cacao fat varies according as it has been obtained by pressure or extracted with solvents. According to White*) it can only be determined with accuracy after the oil has been solidified for many days. Rammsberger states that the expressed fat has a specific gravity 0·85, ether extracted fat 0·99 and that obtained by carbon bisulphide 0·958. Hager gives the normal specific gravity of fresh cacao butter at 15° C. 0·95 to 0·952; old butter 0·945 to 0·946; Dieterich 0·98—0·981 and Allen 0·857**) at 100° C. Its melting point is generally regarded as 33° C.; there is in this respect however a great difference between the expressed and the solvent extracted fat. The expressed fat which has been kept for some time melts between 34° and 35° C.; cacao fat obtained in other ways has a lower melting point. The melting point of cacao fat is determined in the following manner. The melted fat is drawn up into a glass capillary tube of such a size that the fat column is exactly half the length of the mercury ball of the thermometer. As the freshly melted cacao fat alters its melting point, it is necessary to keep the capillary tube in the dark for about 8 days before the melting point becomes constant. The capillary tube is then joined by an indian rubber ring to the ball of the thermometer in such a manner that the fat column is exactly in the middle of the mercury ball. The thermometer and capillary tube are then suspended in a tube of 2½ cm diameter containing water which only reaches part of the way up the capillary tube. The test tube with its contents is then placed in a beaker filled with water which is to be heated. As soon as the fat melts, the surrounding water expels the fat from the capillary tube. The indication then given by the thermometer is the melting point of the fat. Determinations of cacao fat carried out in the manner described gave the following results:

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*) Pharmaceutische Zeitung 1898. Nr. 10.

**) R. Benedikt, Analysis of fats and waxes, p. 530.

	Melting point, centigrade	
Kind of bean:	raw	roasted
Machala Guayaquil	35·5°	34·0°
Caracas	33·5°	34·0°
Ariba	33·75°	31·5°
Port au Prince	34·25°	33·8°
Puerto Cabello	33·50°	33·0°
Surinam	34·20°	34·0°
Trinidad	34·00°	34·0°

White and Braithwaite*) give the following melting points:

Guayaquil	33·6—33·9° C.
Granada	33·0—33·3°
Trinidad	31·5—32·5°
Caracas	33·0—33·6°
Ceylon	33·9—34·2°

Filsinger and Henking**) found:

Kauka	32·1—32·4° C.
Bahia	32·7—33·4°
Porto Plata	33·1—33·6°

These results vary somewhat, but the differences are to be ascribed to the methods employed and to the manner in which the observations of different experimenters are carried out. Generally it may be taken that the melting point of genuine cacao butter should not be under 32° or over 35° C. The fat solidifies between 21·5° and 27·3° C. (solidifying point). The fatty acids from the fat melt at 48°—52° C.; they begin to solidify at 45° C. the solidifying ends mostly at 51—52° C.

Adulteration in cacao fat, as many experiments have shown, cannot be detected by the alteration in melting point. Björklund's ether test which is very suitable for the detection of an admixture of tallow, wax and paraffin, is carried out as follows:

When 3 grammes of cacao butter are dissolved in 6 grammes of ether at 10° C., a clear solution shows absence of wax. The solution is then cooled to 0° C. and the time noted when the solution begins to become cloudy or to deposit white flocculent matter, also the temperature when the solution again becomes clear. If the solution becomes turbid before the lapse of ten minutes the cacao butter is not quite pure. Pure cacao butter becomes turbid in 10—15 minutes at 0° C. and clear again at 19—20° C.; an admixture of 5 percent of tallow renders the solution turbid at 19—20° C. in 8 minutes and it becomes clear again at 22° C.; 15 percent of tallow gives a turbid solution in 4—5 minutes at 0° C. that becomes clear again at 22·5—28·5° C. Filsinger*) has suggested a modification of Björklund's test: 2 grammes of the fat are dissolved in a graduatet tube in a mixture of 4 parts ether (0·725 sp. gr.) and 1 part alcohol (0·810 sp. gr.). Pure cacao butter should remain clear after some time, whereas foreign fats, especially preparations of tallow, produce a separation. This test, however, according to Lewkowitsch**) is not to be depended on, as genuine kinds of cacao butter will crystallize out from the ether alcohol solution at 9° C. and some at 12° C.

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*) Brit. and. Colonial Druggist 1897. Nr. 21.

**) Korr. d. Verb. Deutsch. Schokoladefabr. 1889. Vol. 5, p. 65.

Cacao fat like all fats is saponified by alkalies, that is to say forms a soap or a chemical compound of the fatty acids with alkalies such as potash, soda, ammonia etc. On the addition of a mineral acid to the soap a salt of the mineral acid and alkali is formed with the separation of the fatty acid. The fatty acids are of two kinds:

1. The volatile acids or those which are volatile at 100—110° C. or more easily with steam. These usually exist only in very small quantity in cacao fat but may considerably increase in amount in the fat obtained from improperly fermented beans.***)

2. The solid fatty acids are those which are non volatile in the manner above mentioned; cacao butter consists chiefly of the glycerides of these acids.

Björklund's ether test will detect, as has been stated, admixtures of wax, paraffin, tallow and bodies of a relatively high melting point. Another method must therefore be followed to detect fat of low melting points, as cocoa nut fat, or liquid oils like cotton seed and sesame oils. The methods adopted with cacao fat are the determinations of the iodine value and the saponification and acid values, the melting point of the fatty acids, the refractive index with Zeiss's butyro-refractometer, and the Reichert-Meissl number.

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*) Zeitschrift für analyt. Chem. Vol. 19, p. 246.

**) Journ. Soc. Chem. Ind. 1899, p. 556.

***) The Reichert-Meissl number (to be discussed later) according to a communication from P. Welmanns searcely reachs 1° Burstyn in the expressed fat and amounts to 1·6 cc in the extracted fat (number of cc of normal potash solution to 100 grammes of fat).

The iodine value indicates the amount of iodine per cent absorbed by the fat; consequently it is a measure of the unsaturated fatty acids. As these latter differ in amount in vegetable and animal fats, although constant for each kind of fat, it is possible by the iodine number to recognize a genuine cacao fat and to detect adulteration. The determination of the iodine value is carried out by Hübl's*) method, and according to the experience of Filsinger**) it is advisable to allow the iodine solution to act on the fat for 10—12 hours in diffused daylight. Before determining the iodine value in cacao fat the latter according to Welmans***) should be dried at 100°—105° C. to expel the acrolein produced by too high roasting, but avoiding drying at too high a temperature as then acrolein is easily produced. Filsinger has determined the iodine value of many kinds of cacao butter with the following results:

Kind	Iodine value
Bahia	36·2—36·7
Ariba	36·8—37·1
Kauka	36·6—36·9
Porto Plata	35·1—36·8

Genuine cacao butter shows an average iodine value of 33—37·5. Strohl†) has however obtained with a Bahia fat an iodine value 41,7 but this may be due to the beans having been over roasted or to the fat having been extracted by a petroleum ether of high boiling point.

The saponification value or Köttstorfer's number††) expresses the number of milligrammes of potassium hydrate required for the complete saponification of 1 gramme of fat or in other words the amount of potassium hydrate in tenths percent. According to Filsinger*) this amounts to 192—202 in genuine cacao butter but usually to 194—195. Its determination will detect an admixture of cocoa nut fat.

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*) Dinglers polytechn. Journal, Vol. 253, p. 281. For details of the method compare also P. Welmans Zeitschr. f. öffent. Chemie 1900: Nr. 5.

**) Zeitschr. f. anal. Chemie 1896, p. 519.

***) Zeitschr. f. öffent. Chemie 1900, p. 95.

†) Zeitschr. f. anal. Chemie 1896, Vol. 35, 166.

††) Ibid. 1882, Vol. 21, 394.

The determination of the acid value has lately become of importance since the introduction of the so called Dutch IIa cacao butter or shell butter which has been obtained from cacao refuse and is generally rancid. This value or number expresses the amount of potassium hydrate in tenths percent or the number of milligrammes of potassium hydrate necessary to neutralize the free fatty acids in one gramme of fat and is therefore a measure of the amount of free fatty acid. As this constant has been differently stated according to the method adopted (Merz, Burstyn) it is necessary to take this into account in reading the literature on the subject. It must not be overlooked that the method of preparation, the age of the beans, as well as of the fat, all have an influence in increasing the acid value.

The Reichert-Meissl value expresses the potassium hydrate value of the volatile fatty acids present in the fat; they amount as already mentioned to 1·6 cc normal potassium hydrate in the extracted cacao fat; milk chocolate according to Welmans yields a fat having a Reichert-Meissl value of 2·5.

The determination of the refractive index in Zeiss's butyro-refractometer is of value for ascertaining the purity of cacao butter, and it serves as a control on the iodine value, as according to Roques**) the refractive index and the iodine value stand in equal relation, so that fat having a high iodine value gives a high refractive index and vice versa. The refractive index of cacao fat ranges at 40° C. between 1·4565—1·4578 which corresponds to 46—47·8° on Zeiss's scale. The refractometer indication is recommended by Filsinger as a preliminary test of cacao butter, since with a normal refraction it is not necessary to proceed further and determine the iodine, saponification and acid values, and the melting point.

For further information on all these methods the reader is referred to the excellent work by R. Benedikt "Analysis of Fats and Waxes". V. Edition, Berlin 1897, pp. 530—531.

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*) Correspond. d. Verb. d. deutsch. Schokolade-Fabr. 1889. Vol. X. Nr. 5.

**) Zeitsch. für angew. Chem. 1898. p. 116.

The shells or husks of the cacao beans also contain fat, amounting however only to 4—5 percent, but latterly it has been found worth recovering. As already mentioned, it is commercially known as Dutch IIa cacao or artificial cacao butter, and cannot have been obtained like the fat of the kernel by mechanical means but extracted by a cheap solvent such as petroleum spirit or benzene. The smell of benzene is very difficult to remove from the shell butter, consequently it has little commercial value and its manufacture is unremunerative. Shell butter according to Filsinger has a higher iodine value than the kernel butter namely 39 to 40; its acid value, especially if the fat is rancid, can reach 50—60°, Burstyn (parts by volume, not parts by weight).*) If the shell butter be treated with sodium carbonate or magnesium carbonate the neutral fat then has the normal iodine value of pure cacao butter, namely 36·5. In a sample giving an abnormally high iodine value it is always necessary to determine the acid value, and if the latter be too high the fatty acids must be removed; in a genuine sample the normal iodine value will then be obtained. (Filsinger.)

Cacao butter has a considerable commercial value and is consequently liable to sophistication with many inferior fats of vegetable and animal origin. Among these are especially beef and mutton tallow, purified fatty acids of palm nut oil (kakaoline), wax, paraffin, stearic acid, dicka fat (nucoa butter?) and cocoa nut fat, as well as the various preparations of the last which are met with in commerce under the name of Mannheim cocoa nut butter, vegetaline, lactine, finest plant butter, chocolate butter, laureol, vegetable butter, palmin, kunerol etc.; less commonly used are cotton seed oil, sesame, earth nut oil, margarine and hazel nut oil.

Adulteration can be detected by the above described reactions and analytical methods. According to R. Benedikt**) the presence of wax and paraffin considerably diminishes the saponification value, cocoa nut fat increases it and lowers the iodine value, whereas stearic acid raises the acid value. The presence of cocoa nut fat can also be shown according to A. Ruffin*) by the etherification of the fatty acids with alcohol and sulphuric acid when the characteristic odour of the ethyl ether of cocoa nut acid is produced. Tallow can be recognized by Björklund's test. Vegetable oils, such as almond, cotton seed, earth nut, sesame, hazel nut oils, lower the melting point of the fatty acids and raise the iodine value. Sesame oil is also easily detected by Baudouin's reaction which can be carried out by gently warming 2 cc of cacao fat with a freshly prepared mixture of 1 cc hydrochloric acid (1·18 sp. gr.) and 5 — 10 centigrammes of cane sugar. The presence of sesame oil is shown by a raspberry coloration whilst pure cacao fat yields a fine yellow or dark brown. Baudouin's reaction will detect 1 percent of sesame in cacao butter.

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*) These high acid values may also be due to acidity of the benzene employed in the extraction of the cacao butter.

**) R. Benedikt, Analysis of fats and waxes, p. 532.

The following table, containing the analytical results of the fatty substances which are chiefly employed to adulterate cacao fat, will serve to facilitate reference to this subject.

(See table p. 45.)

In addition to its use in the manufacture of certain cacao preparations and for lubricating parts of machinery which come into contact with the cacao etc., cacao butter is also used in perfumery and especially in pharmacy for making suppositories, ointments, etc., but is of no importance in soap making. As an edible fat, in the true sense of the word, cacao butter is not used in an unmixed condition owing to its indigestibility; but when in the form of chocolate according to the studies of Benedix**) it is as well digested by the human organism as milk fat which is commonly regarded as in the most favourable condition for absorption in the intestinal canal. The digestibility of both fats varies from 92·3—95·38 percent, and both, in this respect, stand very near to cocoa nut fat, from which the soluble glycerides have been removed, and to cow butter, the former according to Bourot and Jean***) is digestible to the extent of 98 and the latter 95,8 percent.

Cacao butter is obtained as a bye product in the preparation of cacao powder, and in every country where cacao powder is produced there is always a large trade in cacao fat.

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*) Pharmaceutische Rundschau 1899, Nr. 51, p. 820.

**) Therapeutische Monatshefte 1895, p. 345.

***) Compt. rendus de l'acad. des sciences de Paris, Vol. 123, p. 587.

	Melting point °C.	Melting point of fatty acids °C.	Iodine value	Saponification value	Acid value	Refractive index in Zeiss's butyrometer
Cacao butter	30—34·5	48—52	34—37·5	192—202	9·24—17·9	46—47·8 at 40° C.
Almond oil	—	14	93—101·9	189·5—195·4	—	64—64·8 at 25° C.
Sesame oil	—	26—30	106·4—109	187—192	—	67—69 at 25° C.
Earth nut (Arachis) oil	—	27—31	92—101	190—197	—	65·8—67·5 at 25° C.
Hazel nut oil	—	17—25	83·2—88	191·4—197·1	—	—
Cotton seed oil	—	38—40	106—111	191—197	—	67·6—69·4 at 25° C.
Oleo-margarine	32·4—32·5	42	43·8—48·5	195—197·4	—	48·6 at 40° C.
Beef tallow	43—49	43—46	35·4—36·5	193·2—198	—	49 at 40° C.
Wax	62—64	—	8·0—11	97—107	19—21	—
Paraffin	38—82	—	3·9—4	—	—	—
Stearic acid	71—71·5	—	—	195—200	195—200	—
Sebin	37·6—37·8	—	43·7—43·8	192·4—192·6	—	—
Cocoa nut fat	20—28 chiefly 26·2—26·4	24—25	8—9	254·8—268·4	—	35·5 at 40° C.

That is especially the case in Holland where the monthly supply to the Amsterdam market is so large that during 1899 one firm alone — Van Houten — had 855 tons for sale. The average price of late years has considerably increased and is now about 64—73 cents per kilogramme.

Cacao-red or cacao pigment.

Some investigators have assigned the peculiar aroma and the taste of the cacao bean, to a great extent, to the cacao-red or cacao-pigment. As previously pointed out the young, fresh bean is colourless, the pigment forming later, as can be observed in many vegetable colouring materials, as for example, oak- and cinchona-red, madder, indigo and kola nut red (from Sterculia acuminata). As the later investigations of Hilger *) have shown, the fresh colourless cacao bean contains a diastasic ferment, as well as a glucoside body, which C. Schweitzer**) has termed cacao glucoside or cacaonin.***) In the drying of the ripe white seeds the cacao glucoside is partly decomposed by the diastasic ferment with formation of starch-sugar, the pure non-nitrogenous cacao-red, as well as theobromine and caffeine; substances which, together with a certain amount of undecomposed cacao glucoside, can be detected in the seed which has then acquired a brownish to violet colour. The unfermented bean, according to Schweitzer, has as much as 0,6 percent of unaltered glucoside. Fermentation produces the same effect as drying, as here again the glucoside is not completely split up, for the cacao-red, isolated in the ordinary way, consists according to Hilger of a mixture of pure non-nitrogenous cacao-red and some glucoside.

The complete decomposition of the cacao glucoside is only capable of being effected in a chemical manner, namely by boiling the finely divided and defatted seeds with dilute acids, a method which does now render possible the exact determination of the diureides, as the acid treatment sets free the whole of the theobromine and caffeine.

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*) Apotheker Zeitung 1892, p. 469 and Deutsche Vierteljahrsschrift für öffentl. Gesundheitspflege. 1893, Nr. 3.

**) Pharmaceut. Zeitung 1898, p. 389.

***) The term glucoside includes those bodies, the greater number of which occur in plants, which by treatment with alkalies, acids or ferments are split up into an indifferent body and a sugar, generally glucose. These bodies may be chemically regarded as ethereal derivatives of the respective sugars.

The molecule of cacao glucoside according to Schweitzer is to be regarded as an ester which consists of one molecule of non-nitrogenous cacao-red, six molecules of starch-sugar and one molecule of theobromine with double-sided attachment and having the empirical formula $C_{60} H_{86} O_{15} N_4$.

All statements of a chemical nature respecting cacao-red before the appearance of Hilger's experiences related to a mixture of a pure non-nitrogenous pigment with the glucoside. Before the pure pigment can be prepared it is necessary to obtain the cacao-red glucoside mixture. That can be done according to Hilger and Lazarus*) by treating the roasted beans with petroleum ether, which removes the fat and a part of the free theobromine, then with water to extract the remaining theobromine, caffeine, sugar and salts, and finally with alcohol to extract the "cacao-red". The alcoholic residue is then quickly dried on porous plates. The material thus obtained is a reddish brown amorphous bitter powder which is scarcely soluble in water, easily in alcohol or in dilute alkali, and is reprecipitated by acid from its alkaline solution. It gives a sublimate of theobromine when heated. When boiled with 5 percent sulphuric acid it is completely decomposed into sugar, theobromine, caffeine and the real cacao-red. The last has the formula $C_{17} H_{12} (OH)_{10}$. It appears to stand in near relation to tannin, which it resembles in yielding formic acid, acetic acid, and pyrocatechin by the action of caustic alkalies. The pure non-nitrogenous cacao-red, at present, is exclusively of scientific interest; for practical purposes only the crude cacao-red, cacao-red + glucoside, as naturally existing in the bean is of importance. The better and more effectual manner in which the beans have been prepared by fermentation, the more intense is the formation of the cacao-red, especially its localisation in the cells and cell tissues. This is the reason that the colour of the various kinds of beans and of their aqueous extracts is so different. Especially is this noticeable in carelessly dried beans in which the cotyledon tissues are of a dirty brown or yellow colour instead of a brown or violet colour; in that case the pigment is not restricted to separate cells but has the appearance of having penetrated into the contiguous albuminous cells.

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*) Compare: Schweitzer, Pharmaceut. Zeitung 1898, p. 389.

The bean contains 2·6—5 percent of the crude cacao-red; it is soluble in alcohol and in ether and partly so in hot water and is completely extracted from the bean by weak acetic acid. The crude cacao-red can be determined quantitatively by precipitating its solution with lead acetate, decomposing the lead precipitate with sulphuretted hydrogen and evaporating the filtrate containing the cacao-red to dryness.

The aqueous extract of the beans, which contains the cacao-red, is coloured greenish brown by alkalies, red by acids: acetates give a grey to yellowish colour; tincture of iodine, stannous chloride and mercurous nitrate give a rose to brown precipitate. Iron and copper salts produce grey precipitates which gradually become brown to black. Gelatin solution, containing alum, and albumin give copious yellow precipitates.

Stains produced on linen by the colouring matter of cacao-red can be removed by treatment with hot water and finally bleaching with a solution of sulphurous acid.

Theobromine.

All those materials which are regarded as stimulants like coffee, tea, cacao, tobacco etc., owe their action to peculiar nerve stimulating bodies, which are present only in small quantity in the seeds or leaves of the respective plants and are termed by chemists alkaloids and diureides.

The physiologically active constituents of tea, coffee and cacao are considered, even up to day, by many authors as alkaloids or organic bases and especially ranked among the xanthine or purine bases. Recent investigations separate however these substances from the alkaloids in the strict sense and comprise them within a particular group of urea derivatives under the designation of ureides; the ureides of tea, coffee and cacao, representing two molecules of urea, they are to be qualified as "diureides".

A bitter substance in cacao bean had already been observed by Schrader, but Woscressensky*) in 1841 was the first to isolate the diureide, theobromine.

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*) Annalen der Chem. and Pharm. 1841. Vol. 41, p. 125.

Theobromine is found in the unfermented and fermented beans in two forms; as free theobromine, which has been eliminated from the glucoside by the ferment in the drying and fermenting processes, and in combination with glucose and cacao-red as a glucoside, from which it can only be separated by chemical means.

Theobromine stands in near relation to caffeine, the diureide of tea and coffee, as will be seen from their chemical formulæ in which theobromine is shown to contain one methyl group CH_3, less:

$$\overbrace{C_5\,H\,N_4\,O_2\,(CH_3)_3}^{\text{Caffeine}}; \qquad \overbrace{C_5\,H_2\,N_4\,O_2\,(CH_3)_2}^{\text{Theobromine}};$$

Strecker*) was the first to show the relation of theobromine to caffeine when he succeeded in converting theobromine into caffeine by the action of methyl iodide on silver theobromine for 24 hours at 100° C. Caffeine and silver iodide are then formed and can be separated by treatment with alcohol, which dissolves the caffeine leaving the silver iodide undissolved.

E. Fischer**) has shown the relation of theobromine and caffeine to uric acid, by artificial synthesis of both substances from derivatives of uric acid. Fischer starting with monomethyl-pseudo-uric acid converted it into 7-methyl-uric acid by boiling it with hydrochloric acid and then, by treating the lead salt of the latter with methyl iodide and ether, produced 3—7-methyl-uric acid. That acid was converted into dimethyl-dioxychlor-purine by treatment with a mixture of phosphorus oxychloride and phosphoric pentachloride, then into the corresponding amine by heating with ammonia and then by further treatment with phosphorus oxychloride, with subsequent reduction, into 3—7-dimethyl-6-amino-2-oxy-purine from which, by the action of nitrous acid with the loss of the amine group, theobromine was finally obtained. The synthesis of theobromine is a brillant exploit of Fischer's and it is quite possible that, at no distant time, when a simple and cheap method has been found, synthetical theobromine will appear commercially as a rival to the natural product. At present there is no prospect of this occurring and cacao shells from which theobromine is now prepared still serve for that purpose as a useful bye product in the manufacture of cacao.

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*) Annalen der Chem. und Pharm. Vol. 118, p. 151.

**) Berliner Chemische Berichte 1897, p. 1839.

Theobromine and caffeine like the alkaloids or plant bases have a distinct physiological action and even a toxic action if taken in too large a quantity.

From the experiments of Mitscherlich it appears that theobromine has a similar action to caffeine, but is somewhat less active owing to being less soluble in the gastric juice. Mitscherlich's experiments with frogs, pigeons and rabbits show that 0,05 gramme killed a frog in 40 hours, 0,5 gramme a pigeon in 24 hours, and 1 gramme a rabbit in less than 20 hours. Death resulted in all cases from action on the spinal cord, producing either convulsions or subsequent paralysis.

The results of these experiments do not depreciate the nutritive value of cacao since the human organism requires ten times as much theobromine as rabbits do to exhibit the slightest toxic symptom; in cacao mass containing 1 percent of theobromine that would represent 2500 grammes of chocolate.

It appears from the experiments of Albanese,*) Bondzynski, Gottlieb**) and Rost***) that 3 percent of the theobromine administered passes out in the urine unaltered, whilst 20—30 percent of that decomposed in the organism is found as monomethyl-xanthine. The excretion of theobromine appears to be closely connected with the quantity of urine voided, which is especially increased by the administration of theobromine. Since 1890, as a result of W. v. Schröder's†) observations in 1888, that property of theobromine has had an extended application in practical therapeutics; theobromine has been used as a diuretic in kidney diseases, and, unlike all similar medicinal agents, it exercises no influence on the heart, a circumstance which essentially increases its therapeutic value. It can be employed for medicinal purposes, either uncombined or in the form of salicylate, acetate and certain double compounds, as sodium or lithium and theobromine salicylate or acetate.

The double compounds known as diuretin, agurin and uropherin are freely soluble in water and are therefore more readily absorbed into the system than pure theobromine which is very sparingly soluble in water. Through the introduction of theobromine as a medicinal agent for which we are indebted to Chr. Gram*) and G. See**) cacao husks, hitherto, a waste product in the manufacture of cacao, have become of value for the preparation of theobromine, in which many of the largest German chemical manufacturers are now engaged.

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*) Archiv f. experimentelle Pathol. und Pharmacol. 1895. Vol. 35, p. 449.

**) Ibid. 1896. Vol. 36, p. 53.

***) Ibid. 1896. Vol. 36, p. 66.

†) Ibid. 1888. Vol. 24, p. 101.

Methods for the determination of theobromine are so numerous that it is impossible here to discuss their relative merits. Therefore only the method of Eminger***) will be described as it corresponds best with our present knowledge of the subject and its practical requirements; moreover the process can be recommended to technical and food chemists as trustworthy.

10 grammes of powdered cacao beans or cacao preparation are placed in a weighed glass flask, then agitated with 100 grammes of petroleum ether and allowed to settle. The petroleum ether is carefully poured off and the treatment repeated several times. After the last decantation the residue is well drained, then dried in the flask and weighed. The difference in weight of the residue represents fat. An aliquot portion of the residue (about 5 grammes) is then boiled with 100 grammes of a 3—4 percent sulphuric acid in a flask, which is connected with a reflux condenser, until cacao-red is produced which occupies three quarters of an hour. The contents of the flask are then poured into a beaker and neutralized, whilst hot, with barium hydroxide. The whole is then mixed with sand in a basin and evaporated to dryness; the dry residue is placed in a paper cone in a Soxhlet apparatus and extracted for 5 hours with 150 grammes of chloroform. The chloroform is cautiously distilled off and the residue dried for one hour at 100° C. This residue consists of some fat and a mixture of caffeine and theobromine. For practical purposes the separation of the two diureides is not necessary and in commercial analyses it is sufficient to state the amount of both substances, after the removal of fat by a suitable solvent. But should separation be necessary, then Eminger's method should be adopted, which depends on the solubility

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*) Therapeutische Monatshefte 1890, p. 10.

**) Semaine médicale 1893, p. 366.

***) Forschungs-Berichte über Lebensmittel etc. 1896. Vol. III. p. 275. and Beckurt's Jahresber. der Pharmacie 1896. p. 746.

of caffeine in carbon tetrachloride.*) With that object the mixture of fat, theobromine and caffeine is treated in the flask with 100 grammes of carbon tetrachloride for one hour and repeatedly agitated. After filtration the carbon tetrachloride containing fat and caffeine, is distilled off, the residue repeatedly boiled with water, and the aqueous solution evaporated to dryness in a weighed basin (caffeine). The theobromine left in the flask undissolved by carbon tetrachloride and the filter used to filter the carbon tetrachloride solution of caffeine are then extracted with boiling water, the solution is filtered and evaporated to dryness, the residue representing the theobromine. The separation of caffeine and theobromine can also be effected by câutious treatment with caustic soda which dissolves theobromine and not a trace of caffeine. (Riederer.)**)

Eminger found from 0·88 — 2·34 percent theobromine in the examination of a great number of commercial kinds of cacao beans and in the husks 0·76 percent of the diureide: C. C. Keller***) has also found it in the leaves and in the pericarp. Cacao contains 0·05 to 0·36 percent caffeine.

Theobromine is a permanent white powder which appears under the magnifying glass as small white prismatic or granular crystals. At first it has only a slightly bitter taste which becomes more intense when kept longer in the mouth, and indeed the bitter taste of the cacao bean and its preparations is mostly due to theobromine. It sublimes at 220° C. without melting. That phenomenon explains how it is that the over-roasted bean, that is, the kernel of beans which by accident have been heated to more than 130—150° C. is poorer in theobromine than the husks. When heated to 310° C. theobromine melts to a clear liquid which re-crystallizes on cooling.

One part of absolutely pure theobromine dissolves according to Eminger in 736·5 parts of water at 18° C., in 136 parts at 100° C., in 5399 parts alcohol (90 percent) at 18° C., in 440 parts boiling 90 percent alcohol and in 818 parts of boiling absolute alcohol. It dissolves in 21 000 parts of ether at 17° C., in 4856 parts of methyl alcohol at

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*) The solubility of caffeine in carbon tetrachloride is stated by Eminger to be 1 : 100 but, according to Schnerr, a much larger quantity is required.

**) Pharmaceutische Centralhalle 1898. p. 901.

***) Schweizerische Wochenschrift f. Chemie u. Pharmacie 1895. p. 453.

18° C., in 5808 parts of chloroform at 18° C. and in 2710 parts of boiling chloroform. Theobromine is partly decomposed by strong alkalies but by cautious addition of alkalies it forms compounds with them, which are readily dissolved by solutions of sodium salicylate, acetate or benzoate. These double compounds under the name of diuretin, agurin and uropherin have lately become of therapeutic value.*) Sodium silicate and more particularly trisodiumphosphate according to Brissemoret**) are great solvents of theobromine. One and a half molecule of the latter salt can dissolve one molecule of theobromine so that in this way it is possible to prepare a solution containing nearly 2 percent. Phenol also dissolves a large quantity of theobromine according to Maupy***) who has utilised this property for the determination of theobromine. The defatted cacao preparation is moistened with water and extracted with a mixture consisting of 15 percent phenol and 85 percent chloroform.

Theobromine like caffeine gives the murexide reaction when treated with chlorine water — forming amalic acid — and rapidly dried down on a watch glass with addition of a drop of ammonia at the end of the operation. The residue thus obtained has a violet colour which serves to distinguish theobromine readily from other plant bases which do not belong to the xanthine group.

Although theobromine is the most valuable constituent of cacao beans the importance attached to a greater or lesser amount in the beans as a commercial article was formerly much exaggerated.

The latest investigations of Dragendorff and others have shown that the value of various stimulants like tobacco, coffee and tea, does not entirely depend on the amount of alkaloid or diureide but partly also on the joint action of all the constituents of those articles, and it is particularly the aromatic bodies which determine their commercial value. Various kinds of coffee, for example, of inferior commercial value contain considerably more caffeine than the costly Mocha beans. The highly prized Havana tobacco ranges lower than the Sumatra kinds in nicotine contents, and the same conclusion with regard to cacao would probably be correct. In support of this view, attention may be directed to the following analyses performed by Wolfram.*)

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*) See before.

**) Journal de Pharmacie et de Chimie 1898. p. 176.

***) Ibidem 1897. p. 329.

	Percentage of theobromine	
	In the bean	In the husks
Caracas	1·63	1·11
Guayaquil (of considerably less value than the first)	1·63	0·97
Domingo	1·66	0·56
Bahia	1·64	0·71
Puerto Cabello, fine kind	1·46	0·81
Tabasca	1·34	0·42
Average	1·56	0·76

Excluding the theobromine in the husks which are not used in the preparation of cacao, it will be seen from the above table that the Caracas bean, which is the finest and dearest, has an amount of theobromine which is only equal to, or even a little less than, that in the inferior beans from Guayaquil and Domingo.

5. Albumin.

On the considerable amount of albuminous bodies in the cacao bean, varying between 14—15 percent, depends to a great extent its nutrive value. The albumin in plants, unfortunately, is not present in a form suitable for direct absorption and assimilation by the animal organism, in fact, only a fraction of it is so available. Before considering the nutritive value of the albumin of the cacao bean it will be well to give attention to the general chemical and physical properties of albumin so far as a knowledge of them will assist in the elucidation of the subsequent matter.

Albuminous bodies or proteins occur either dissolved in the sap of plants or in a solid form in the protoplasm of plant cells; also in the form of granular deposits (Aleuron granules.)**) In cacao they are present to all appearance in the three different conditions.

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*) Zeitschrift für analytische Chemie Vol. 18, p. 346.

**) Aleuron granules were first microscopically observed by H. Molisch (Grundriss einer Histochemie d. pflanzl. Genussmittel, page 22) in the cellular tissues of the cacao bean. They are very similar to the starch granules of the bean and contain within them a relatively large globoid [lime and magnesium phosphates associated with an organic substance (sugar)] which becomes visible in the form of globules when a section is incinerated.

The term vegetable albumin, in the more restricted sense, is meant to designate a protein substance which is soluble in water and is coagulable by heat. The greater part of the proteid which exists in the seeds and sap of plants and is coagulable by heat, is not albumin but globulin, that is to say, it is insoluble in water though dissolved by solutions of neutral salts. Whilst many protein substances in aqueous solution require a temperature of 100° C. before being coagulated, that is, becoming insoluble under usual conditions, others coagulate at 65° C. Concentrated acetic acid dissolves all albuminous bodies with the aid of heat, concentrated nitric acid gives a yellow coloration (xantoprotein re-action). Albuminous substances are decomposed when heated to 150° C. becoming dark in colour, swelling up and evolving an offensive smell, finally leaving behind a difficultly combustible coaly residue.

Globulins combine with aqueous solutions of alkalies such as potash, soda, ammonia etc. producing alkaline albuminates; with acids they form acid albuminates or syntonins. Both have the property in common, that whilst they are insoluble in pure water, they readily dissolve in slightly acidulated or alkaline water, as well as in weak saline solutions, and are then no longer coagulable by boiling.

Albuminous bodies are converted first into albumoses (proteoses) then into peptones by gastric and intestinal digestion or by hydrolytic decomposition with acids or alkalies, also by the action of steam under pressure of many atmospheres, as well by putrefaction. Albumoses with the exception of hetero-albumose are soluble in water. Peptones dissolve entirely and in that condition are absorbed by the animal organism.

Albumins are precipitated from their solutions by strong alcohol, and in that way I succeeded in precipitating 4·25 percent of albumin from the aqueous extract of Trinidad cacao, which corresponds to about 25 percent of the total amount of albumin in the bean.

The results of my investigation have shown that generally more soluble albumin is present in the unfermented bean than in the fermented. Consequently, it would appear that in the finer kinds of cacao beans, in which very careful fermentation has been carried out, the albumin, owing to fermentative alteration, is rendered less soluble.

The constitution of albumin is still not sufficiently known; generally it is regarded as having the formula: $C_{72} H_{112} N_{18} SO_{22}$ as inferred from the elementary analysis:

C = 52·31—24·33 percent
H = 7·13— 7·73 „
N = 15·49—17·60 „
S = 0·76— 1·55 „
O = 20·55—22·98 „

Having ascertained the amount of nitrogen, it is possible with the assistance of this formula to determine, by calculation, the amount of albumin contained in plants, from the ascertained percentage amount of nitrogen in the particular plant. The determination of nitrogen is effected by mixing 0,5 gramme of the finely powdered bean with soda-lime and burning the mixture in a tube. Ammonia is formed, which is passed through a known quantity of sulphuric acid. When the combustion is finished, the acid solution is titrated with a standard solution of barium hydroxide, and from the quantity consumed the percentage of nitrogen is calculated. But as the diureides also contain nitrogen (31·1 percent of the theobromine and caffeine present in the bean) the nitrogen corresponding to the amount of diureides must be deducted from the total quantity of nitrogen ascertained by combustion, and the remainder multiplied by 6,25 will indicate the amount of albumin.

A better method for the determination of the nitrogen is by Kjeldahl's*) process. Kjeldahl's process has received various modifications but was originally carried out as follows; the nitrogenous substance (0·25—1·0 gramme in the case of cacao preparations) is mixed with 20 ccm of concentrated sulphuric acid and one drop of mercury; the mixture is then heated on the sand bath until it becomes colourless or only slightly yellow. The solution is diluted, made alkaline, and after addition of potassium or sodium sulphide is distilled; the ammonia passing over is collected and determined as above described. As this method also determines the total amount of nitrogen, an allowance must be made for the nitrogen in the theobromine and caffeine before multiplying the result by 6·25. Cacao powder contains on the average 20 percent of albuminoids and chocolate 8 to 9 percent.

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*) Zeitschrift für analytische Chemie Vol. 22, p. 366.

The albumin in cacao, as previously mentioned, is in the form of globulin, that is in the less soluble form. In cacao preparations which are required for invalids, especially those with affections of the stomach, it is important to have the albumin in a more "readily soluble condition". Various attempts have been made with cacao preparations to obtain that result, and later on, full illustrations and explanation will be given on this subject. First of all, however, it is desirable to consider the scientific methods employed to ascertain the relative digestibility or indigestibility of albumin.

Professor Stutzer*) of Koenigsberg has been engaged in determining the action of digestive ferments of the animal organism on alimentary substances and has worked out a method by which it is possible to ascertain the proportion of albuminous substance which can be regarded as digestible.

The method depends upon the fact that salivary, gastric and intestinal digestion can be artificially imitated in the laboratory. But as the salivary secretion only digests starch and it is difficult to obtain, malt diastase, which serves the same purpose is used instead. On the other hand albuminous material is only digested by juices of the stomach and intestines.

Gastric juice is obtained from the mucous membrane of the fresh stomach of the pig, and it is mixed with 0·2 percent of hydrochloric acid. This is added to the finely powdered substance, and the whole kept at the temperature of the blood (38° C.) for ten hours. It is then filtered, the residue washed, the solution evaporated to dryness and the residue weighed. After making allowance for the solid material in the gastric juice used, the weight of the residue gives the quantity of soluble albumin. K. Wedemeyer**) has improved Stutzer's method by using pepsin instead of the gastric juice of the pig. The process is as follows: 2 grammes of the finely powdered cacao preparation are mixed in a beaker with 490 ccm of water containing 1 gramme of pepsin and 10 ccm of 25 percent hydrochloric acid. The mixture is allowed to digest with frequent shaking at 37—40° C. and after 24 hours again 10 ccm hydrochloric acid are added. After 48 hours it is then filtered, the undissolved substance washed on the filter successively with hot water, alcohol, and ether, and the operation then continued as above described. In the same manner the undissolved portion is then treated with pancreatic juice, prepared from the fresh ox-pancreas, and 0·25 percent of sodium carbonate. The portion thus dissolved, and obtained by evaporating to dryness, is described as albumin dissolved by the pancreas. If the sum of the albumin soluble in gastric and pancreatic juices be deducted from the total amount of albumin found as the results of combustion there remains the insoluble albumin.

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*) Zeitschrift für physiologische Chemie, Vol. 11, p. 207 - 232.

**) Landwirtschaftliche Versuchs-Stationen 1899. Vol. 51, p. 375—385.

Applying those methods to a cacao powder containing 16 percent of total albumin the following results would probably be obtained by this method.

16 % total albumin containing on the average	7·6 % soluble in the stomach
	2·8 % solubles in the intestine
	5·6 % insoluble.

The later experiments of Forster*) however show that artificial digestion does not correctly represent the actual consumption of nutriment in the human body. Forster's experiments in which cacao powder was administered to healthy men gave a much higher value, in fact, 80 percent of the nitrogenous substance was digested, against 60 percent by Stutzer's artificial method of digestion. The results obtained by artificial digestion must therefore be increased in that proportion.

6. Starch.

Starch is one of the most important constituents of cacao, as on the starch, together with fat and albumin, depends the nutritive value of the cacao bean. As previously stated, cacao starch is one of the smallest kinds which occur in the plant kingdom; consequently it can easily be distinguished from the starch granules of other plants. Owing to their minuteness the concentric rings showing the stratified structure of the starch granules can only be distinguished with difficulty under the microscope. Cacao starch consists usually of globular granules, generally separate, but sometimes in aggregations of two or more granules. The appearance under the microscope of the starch granules in the tissue of the cacao bean is clearly shown in fig. 9 which represents a section of Ariba cacao enlarged 750 times. (E. S. Bastin.)*)

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*) Hygienische Rundschau 1900. p. 314 and 315.

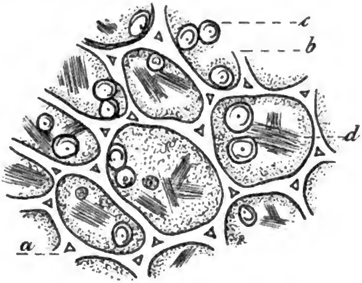

fig. 9.

a represents the intercellular spaces; b the cell walls; c the starch granules; d the fat crystals, those being the contents and structural elements of the cacao cell that the microscope will at once disclose without further treatment.

1. Cacao starch has the usual properties of ordinary kinds of starch, namely:

1. It is gelatinized by hot water, that is to say the water penetrates between the layers of the starch granules separating them and causing by its penetration a swelling up of the starch, whereby a transparent mass known as "starch paste" is produced. It has been stated that cacao starch is less easily gelatinized than the starch of other plants. According to the investigations of Soltsien**) which I absolutely endorse, that is not the case, for, under the necessary conditions, cacao starch gelatinizes just as readly as other kinds of starch.

2. The blue coloration of starch with iodine. The blue coloration of cacao starch with iodine is said to take place more slowly than with other kinds of starch. That also

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*) American Journal of Pharmacy 1894, p. 369.

**) Chemisch technischer Centralanzeiger 1886. No. 53, p. 777.

is not the case, especially if the starch has been previously gelatinized, for then the blue coloration appears immediately on adding a sufficiently strong solution of iodine.

There are certainly other materials in the cacao bean such as fat, which by more or less enveloping the starch, prevent the access of water to the starch granules, and thus hinder gelatinization; or the albumen and cacao-red may exert some retarding influence on the iodine reaction especially if the iodine solution used is very dilute.

According to Soltsien if a mixture of 2 parts of cacao beans with one part of calcinated magnesia and water is heated to boiling, the filtrate immediately gives the blue colour on the addition of iodine solution. On neutralizing the filtrate with acetic acid and adding 3—4 parts of strong alcohol the starch is precipitated.

3. Starch is converted by boiling with dilute acids as well as by the action of ferments such as the saliva, diastase, etc. into starch sugar (glucose, dextrose). The empirical formula for starch is $C_6H_{10}O_5$, that for dextrose $C_6H_{12}O_6$, so that in the conversion, the starch takes up one molecule of water by which its chemical nature is very much changed, especially in becoming freely soluble in water. That alteration allows of starch being quantitatively determined, as the dextrose thus produced has the property of reducing an alkaline solution of copper sulphate (known as Fehling's solution after the discoverer), that is to say the copper sulphate is converted into insoluble red cuprous oxide.

As dextrose always precipitates a definite amount of cuprous oxide the quantity of starch present can in that way be ascertained.

With cacao beans the determination is made in the following manner: in order to render the starch more easily gelatinizable, the fat is first removed by treating 5 grammes of cacao powder or 10 grammes of a cacao preparation with ether and then with 80 percent alcohol, to separate sugar, theobromine and cacao-red. The residue is then mixed with water and subjected to steam-pressure of 3—4 atmospheres which converts the starch into a soluble body, known as amylo-dextrin. This operation is generally carried out in an autoclave or strong copper vessel provided with an air tight cover;*) the open flask, containing the sample to be gelatinized (1 part of cacao and 20 parts of water) being placed in the metal vessel half immersed in water.

After fastening on the cover, the temperature of the interior of the vessel is raised to 133—144° C. corresponding to a pressure of 4 atmospheres and maintained at that pressure for 3—4 hours to allow the action to proceed on the mass for gelatinization of the starch. The flask is then removed from the apparatus and the contents allowed to settle for a few minutes; the liquid is filtered hot, the filter being washed a few times with hot water until the filtrate amounts to 250—300 ccm. The cell fibre only remains on the filter whilst the starch is dissolved in the filtrate; the filtrate is then heated with 20 ccm of hydrochloric acid, in a flask connected with a reflux condenser, for some hours whereby the starch is converted into dextrose. The sugar solution is neutralized with sodium carbonate, clarified with basic lead acetate, any excess of the latter being removed with sodium sulphate, finally filtered and made up to 500 ccm. The sugar is determined in this solution by titration with alkaline copper sulphate solution and from the number of cubic centimetres required for complete precipitation of the red cuprous oxide, the quantity of sugar can be ascertained. As only 99 parts of starch are equal to 108 parts of dextrose or grape sugar the following calculation must be made.

$$\overset{\text{dextrose}}{108} : \overset{\text{starch}}{99} = \text{dextrose found} : X.$$

In the determination of sugar with copper sulphate there is some advantage in using F. Allihn's**) method in which the cuprous oxide is reduced by hydrogen gas to metallic copper, weighed as such and calculated into sugar, or the cuprous oxide can be collected and dried on an asbestos filter and weighed in that condition. The cuprous oxide must be previously washed with hot water, alcohol and ether, which must be completely removed by subsequent drying in the air bath, since even an error of one milligramme would seriously affect the final result.

The chemical determination of starch is only in a limited degree effectual in the recognition of an admixture of foreign starch in cacao preparations. If more than 10—15 percent of starch (calculated on the crude bean) has been found, then it must certainly be assumed that there is an admixture of foreign starch, but chemistry affords no assistance by which foreign starch may be distinguished from the genuine starch of the cacao bean. For that purpose the foreign starch must be observed under the microscope, which not only serves to detect its presence but gives an approximate estimation of the amount present, and its origin. Great caution should be exercised or the results may easily be exaggerated. The details of this method, which is only employed with finished cacao preparations, will be considered, later, in detail.

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*) Soxhlet's steam-digester, made by Esser of Munich.

**) Zeitschrift für analytische Chemie 1882. Vol. 22, p. 448.

7. Cellulose or crude fibre.

This material has already been described as the chief constituent of the cell walls and vascular tissues. It consists according to the latest chemical investigations of the anhydrides of hexose and pentose (sugar compounds) incrustaded with many impurities, such as cacao-red, gum, mucilage etc. From a chemical point of view, cellulose has the same formula as starch namely $C_6H_{10}O_5$ or a multiple of it. One of its chemical properties is solubility in ammonio-cupric sulphate, and its affinity for alkalies such as potash, soda, ammonia, causes it to swell when they act on the cell fibres.

Weender's process*) as worked out by Henneberg is the one usually adopted for the determination of fibre (crude fibre) in plants. The previously defatted substance is treated successively with 1·25 percent each of warm sulphuric acid and potash lye. The insoluble residue is successively washed with water, alcohol and ether, weighed, and after deducting ash is regarded as cellulose. Recently H. Suringar, B. Tollens**) and more particular König***) have pointed out that in Weender's process the so called pentosan (sugar derivative) of the composition of $C_5H_{10}O_5$ which comprises a not inconsiderable part of crude fibre would undergo a disproportionate alteration so that the analytical results thus obtained would not correctly represent the amount of cellulose. The crude fibre must therefore be treated in such a manner as to eliminate the pentosan. König attains that result by treating 3 grammes of the defatted substance with 200 ccm of glycerin (1·23 sp. gr.) containing per litre 20 grammes of concentrated sulphuric acid, under the pressure of 3 atmospheres, for one hour. It is then filtered whilst hot through an asbestos filter and after being washed successively with hot water, alcohol, and ether, it is weighed then burnt and the ash weighed. The difference between the two weighings expresses the amount of ash free crude fibre.

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*) Contribution to the establishment of a rational feeding of ruminants. Weender's Beitraege the 1864 Number, p. 48 u. Landwirt. Versuch.-Stat. Vol. 6, p.497.

**) Zeitschrift für angewandte Chemie 1896. p. 712 and 749.

***) Zeitschr. f. Untersuchung von Nahrungs- und Genussmitteln etc. 1898, p. 3.

Filsinger, the meritorious experimenter on the subject of cacao, has determined by König's method the amount of crude fibre in a series of different kinds of cacao beans and the following results were obtained with shelled and roasted beans.*)

		percent
1.	Puerto Cabello	5·37
2.	Java	3·97
3.	Ariba Guayaquil I	4·10
4.	do. II	4·07
5.	Machala Guayaquil I	4·43
6.	Para	4·01
7.	Surinam Guaiana	3·01
8.	Bahia	2·81
9.	Grenada	3·10
10.	Guatemala	3·50
11.	Machala Guayaquil II	3·58
12.	Caracas	3·65
13.	Samana	4·58
14.	St. Thomé A I	4·13
15.	do. A II	2·95
16.	do. B	3·15
17.	Haiti	3·12

These new values may be provisionally regarded as normal. From these results an opinion can be derived not only as to the working of the cacao shelling machine, but also as to any possible admixture of husk in cacao preparations since the husk contains a great deal more crude fibre than the kernel. Therefore the determination of the crude fibre is an important item in testing cacao preparations as there is no doubt that the presence of vegetable substances rich in crude fibre, such as cacao husk, can be detected by the increase in the amount of cellulose.

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*) Zeitschrift für öffentliche Chemie 1900, p. 223.

8. Sugar and plant acids.

The presence of sugar in raw cacao beans was first pointed out by Schweitzer.*) The sugar is formed by the action of the cacao ferment on the glucoside cacaonin during the operation of drying and fermenting the beans. In addition to sugar, malic and tartaric acids have been observed. These substances however are only of interest to the plant physiologist and not to the manufacturer, so it is sufficient merely to notice them here in passing.

9. The mineral or ash constituents.

When cacao beans are ignited, the constituents of an organic nature are volatilized and only the non-volatile or inorganic constituents remain behind. These consist of potash, soda, lime, iron, magnesia, combined with silicic acid, phosphoric acid, sulphuric acid and chlorine.

The amount of ash in raw and shelled cacao beans varies from 3—4 percent. Tuchen**) found 2·9—3 percent, Trojanowsky***) 2·08—3·93 percent, Zipperer****) 2·7—4 percent, L'Hote†) 2·2—4 percent, H. Beckurts††) 2·20—3·75, T. Hockauf†††) 2·84—4·4 percent. Of those kinds which are now much in use Ceylon gave 3·3 percent, Java 3·20 and Kameroon 2·95 percent. (Beckurts.)

Quantitative analyses of the ash of cacao beans have been made by several investigators, and the following table

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*) Pharmaceutische Zeitung 1898, p. 390.

**) Archiv der Pharmacie 1860, Vol. 153, p. 59.

***) Beitrag zur pharmakol. und chem. Kenntniss des Cacaos. Inaug. Dissertation Dorpat 1875.

****) Untersuchungen über Kakao und dessen Präparate, 1887.

†) Jahresbericht über die Fortschritte der Pharmacognosie etc. 1883, p. 314.

††) Archiv der Pharmacie 1893. Vol. 231, p. 694.

†††) Zeitschrift des allgem. oesterr. Apoth.-Vereins 1898, p. 434.

Analysis of the ash of cacao beans by R. Bensemann:

The ash of the kernel free from husk dried at 100° C. contained:

Insoluble respectively in dilute hydrochloric or nitric acid:	Maracaibo	Caracas	Trinidad	Machala	Porto Cabello	Mean
a) Volatile dessicated at 100° C.	0·142	0·076	0·144	0·074	0·198	0·127
b) Fixed at red heat	0·312	1·663	0·553	0·630	1·075	0·846
Soluble in dilute hydrochloric or nitric acid:						
c) Potassium oxide K_2O	35·889	33·844	30·845	30·686	29·989	32·251
d) Sodium oxide Na_2O	0·515	0·766	1·964	4·173	3·427	2·169
e) Calcium oxide CaO	4·118	5·030	4·638	3·112	2·923	3·964
f) Magnesium oxide MgO	15·750	15·151	16·060	16·172	17·562	16·139
g) Ferric oxide Fe_2O_3	0·182	0·217	0·491	0·629	0·303	0·364
h) Aluminium oxide Al_2O_3	0·080	0·326	0·490	0·432	0·305	0·327
i) Silicic acid SiO_2	0·214	0·211	0·169	0·134	0·240	0·194
k) Phosphoric anhydride P_2O_5	27·741	29·302	28·624	37·000	35·274	31·588
l) Sulphuric anhydride SO_3	2·632	2·740	3·957	2·042	3·952	3·065
m) Chlorine Cl	0·295	0·341	0·427	0·279	0·085	0·285
n) Carbonic anhydride CO_2	10·349	8·435	8·953	2·788	3·481	6·801
o) Water H_2O	1·847	1·975	2·781	1·912	1·205	1·944
Oxygen O equivalent to chlorine	0·066	0·077	0·090	0·063	0·019	0·064

gives a series of the most complete analysis, made by R. Bensemann.*)

In previously describing the aleuron granules of the cacao bean it was mentioned that they contain a comparatively large globoid. According to Molisch**), when sections are cautiously heated on platinum foil, these globules are found in the ash. From their number they give a characteristic appearance to the ash of cacao beans and, thus, may serve as a good means of identifying cacao, since they can be detected in the smallest quantity of a genuine cacao preparation.

A noteworthy fact may here be mentioned, namely, the presence of a small amount of copper in the ash of cacao beans, as well as in the husk. Duclaux***) was the first to point out this fact and several other observers, such as Skalweit†) and Galippe††) have also confirmed it. The amount of copper in the husk varies from 0·02—0·025 percent and in the beans from 0·0009—0·004 percent. (Duclaux.) Copper in similar amount is found in all kinds of the beans and husks, and its presence is due to the absorption of copper by the plant from the soil, whence it gradually accumulates in the fruit.

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*) Repert. f. analyt. Chemie 1885, Vol. 5, p. 178.

**) Grundriss einer Histochemie der pflanzl. Genussmittel, p. 22

***) Bulletin de la société chimique: Paris, 1872, p. 33.

†) Pharmaceut. Zeitung Vol. 24, p. 243.

††) Journ. de Pharm. et de Chim. 1883, Ser. V. Vol. 7. p. 506.

VII. The Cacao shells or husks.

Most of the constituents which exist in the cacao kernels are also to be found in the husks; the methods for isolating and determining them are the same in both cases and have already been described. The composition of the husk according to Laube and Aldendorff*) is as follows:

	Amount of husk	Water	Nitrogenous substance	Fat	Non nitrogenous extractive	Woody fibre	Ash	Sand
	Percent							
Caracas	20·09	7·74	11·68	5·99	35·29	12·79	8·32	18·62
Guayaquil	—	9·11	12·94	10·75	47·08	13·12	6·79	0·21
Trinidad	14·04	8·30	15·14	4·23	46·05	18·00	7·06	0·92
Puerto Cabello . .	14·92	6·40	13·75	4·38	47·12	14·83	6·06	7·46
Soconusco	18·58	6·48	19·12	6·48	39·39	15·67	8·15	4·71
Mean	16·33	7·83	14·29	6·38	45·79	14·69	7·12	5·90

Special analysis**) of the unroasted husks gave the following results:

	Surinam	Caracas	Trinidad	Puerto Cabello	Machala	Port au Prince	Ariba	Mean
	Percent							
Moisture	13·02	11·90	13·09	12·04	—	—	—	12·51
Fat	4·17	4·15	4·74	4·00	—	—	—	4·23
Cacao tannic acid soluble in 80 % alcohol	5·10	3·80	4·87	9·15	—	—	—	4·58
Theobromine . . .	0·33	0·30	0·40	0·32	—	—	—	0·33
Ash	7·31	16·73	7·78	8·99	—	—	—	10·20
Woody fibre . . .	14·85	17·99	18·04	15·98	—	—	—	16·71
Nitrogen	—	2·25	2·13	—	—	—	—	2·19
Proportion of husk in the raw seeds . .	14·60	15·00	14·68	12·28	16·14	16·00	18·68	15·34

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*) König, Die menschlichen Nahrungs- und Genussmittel, Volume 1, p. 261.

**) Zipperer, Untersuchungen über Cacao und dessen Präparate, p. 55.

Roasted cacao husks contain according to G. Paris*) the following constituents:

Moisture 12·57 percent, nitrogenous substance 14·69 percent, fat 3·3 percent, extractives 45·76 percent, crude fibre 16·33 percent and ash 7·35 percent.

50 grammes of the husks when boiled with 500 grammes of water give 25·08 percent extract, 20·68% organic substance, 4·4% ash, 0·21% sugar (reducing substance), 0·79% theobromine 0·12% percent acid, calculated as tartaric acid.

The following constituents have been found by R. Bensemann**) in the ash of cacao husks:

	Maracaibo	Caracas	Trinidad	Machala Guayaquil	Porto Plata
			Percent		
Ash dried at 100° C.					
I. insoluble in dilute hydrochloric or nitric acid:					
a) Volatile dessicated at 100°C	0·113	0·421	0·979	0·306	1·247
b) Fixed at red heat . .	1·917	47·711	29·215	37·662	51·513
II. Soluble in dilute hydrochloric or nitric acid:					
c) Potassium oxide K_2O	31·517	11·812	25·866	23·117	12·174
d) Sodium oxide Na_2O .	4·188	3·298	2·726	1·210	2·780
e) Calcium oxide CaO .	10·134	4·458	5·097	3·503	4·401
f) Magnesium oxide MgO	9·546	4·703	5·206	4·837	4·090
g) Ferric oxide Fe_2O_3 .	0·647	0·931	0 339	0·958	0·462
h) Aluminium oxide Al_2O_3	0·281	1·554	0·710	1·854	1·046
i) Silicic acid SiO_2 . .	1·180	7·975	2·416	4·321	6·780
k) Phosphoric anhydride P_2O_5	9·068	7·630	4·703	7·288	7·242
l) Sulphuric anhydride SO_3	3·041	1·478	3·398	1·741	2·012
m) Chlorine Cl	1·005	0·220	1·022	0·255	0·444
n) Carbonic anhydride CO_2	25·454	5·399	16·290	11·834	4·247
o) Water H_2O	2·135	2·499	2·263	1·171	1·662
p) Oxygen O equivalent to chlorine	0·226	0·049	0·290	0·057	0·100

The amount of husk obtained by various authors, as will be noticed from the results quoted, differs somewhat widely.

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*) Zeitschrift für Untersuchung von Nahrungs- und Genussmitteln 1898 No. 6.

**) Repertorium der analyt. Chemie, 1885. Vol. 5, p. 178.

Laube and Aldendorff, for example, found 14—20 percent while the author obtained 12—18 percent of husks.

These discrepancies are chiefly due to adhering sand and ferruginous earth collected during the drying and fermenting operations. If the beans are carefully collected and kept free from earthy substances, the percentage of husks relatively to that of the bean will appear much lower, and indeed it is now quite possible to obtain properly treated beans containing on the average only 10 percent of husks, with the exception of such beans as Ariba, Machala having very woody husks, in which the amount will reach to 15 percent. The latest machinery for cleaning the beans so completely separates the husk from the kernel that in the finished cacao preparation very little husk is left (less than one percent with beans having thin shells and not over two percent with the thick shell kind of bean [Ariba]). For some years it was not possible to satisfactorily remove the husk and consequently there was always an appreciably large amount of husk in the finished cacao preparations, so that a fraudulent admixture of husk could only be detected with some difficulty. But as the amount of ash in the husk is double that in the kernel, i was possible to form an opinion from the increase in the ash of a cacao preparation, as to an intentional admixture of husk; hence the ash was always required to be determined when suspicion was entertained of the addition of husk. Under existing conditions an addition of husk so large as to increase the amount of ash is scarcely probable, so that to detect small additions other methods must be resorted to, such as the determination of the crude fibre or the silica in the ash*), with microscopic observation, which readily distinguishes the forms of the cotyledon (kernel) mass and those of the husk.

In the following illustration (fig. 10) which has been taken from Mitscherlich's frequently mentioned book, the elementary forms of the cacao husk are clearly observable.

It represents a longitudinal section of the husk of Bahia beans enlarged 300 times and shows, in alphabetical order, six different cell elements. First are to be noticed on the outside, in several parallel series, the compressed cells of the epidermis (a) succeeded by moderately broad and thin walled cellular tissue of the parenchyma (b) which sometimes presents large empty spaces, the result of a loosening of the cell walls through the formation of mucilage. This cellular tissue is also permeated by bundles of spiral vessels (c) which, with the stone cells, are characteristic of the husk, as they exist only in very small quantity in the kernels. Then follow parallel rows of cells (d) resembling epithelial cells; next comes a layer of cells with thick walls, the stone cells (e) and finally several rows of elongated cells (f). A membrane interposes between the husk and the kernel, fragments of which, in the detachment of the kernel, remain adherent to it.

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*) About one tenth part of the ash of the husk consists of Silica.

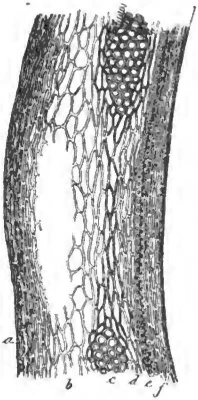

fig. 10.

In examination of the plane surface of the husks enlarged 160 times (fig. 11*) it will be noticed that the characteristic epidermis (ep) consists of large and tolerably long irregular polygonal cells. Frequently on the epidermis may be remarked a delicate net work of cells of the fruit pulp (p). Beneath the epidermis lies a very delicate transverse cellular layer (qu) followed by the parenchyma tissue, as already drawn attention to, at (b) in the sectional drawing. The remaining elementary forms are not readily observed on a plane surface but only in section. For microscopical examination, the husk must first be defatted with petroleum ether or ordinary ether and then treated with dilute chloral hydrate (8:5) to assist the definition of the forms. An approximate estimation of the amount of husk in a cacao preparation can be made by means of the microscope, especially by Filsinger's **) levigation-method, which consists in concentrating those elements of the cacao which are difficultly suspended in water and sink to the bottom when repeatedly agitated with that liquid. The husk especially behaves in that way and microscopic examination is much facilitated. The details of the method will be further described in dealing with the admixture of husk with cacao preparations.

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*) From J. Moeller's Microscopie der Nahrungs- und Genussmittel, p. 323.

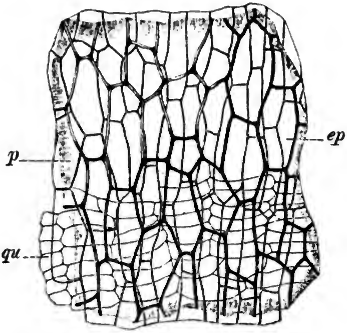

fig. 11.

Cacao husks are the only bye product in the cacao industry, which has developed to such a considerable extent, with corresponding increase of the bye product, that a rational use for the husks has become a matter of urgent necessity. The husks are not used in our industry, for an admixture of husk is not permissible, even in the inferior kinds of chocolate or cacao powder, but must be regarded as an adulteration. The husks have been brought into commerce as cacao tea or coated with sugar to make them tasty; candied husks make a favourite sweetmeat especially in East Germany. But in that way only a comparatively small quantity of husks can be absorbed, so that projects of all kinds have been suggested to work up this bye product. Since 4 and even 5 percent of inferior fat can be extracted from the husk with petroleum spirit, it has become a commercial article known as "Dutch IIa cacao butter"; the husks from which the fat has been removed can be further used for the preparation of theobromine, as already mentioned in the first part of this book.

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*) Zeitschr. für öffentl. Chemie, 1899, p. 27.

Kathreiner's successors in Munich*) employ an extract of cacao husks prepared with hot water, in order to improve coffee berries during the roasting and to give a flavour to coffee substitutes prepared from corn and malt. Cacao extract is also prepared from the husks**) by first treating them with water or steam, then extracting with water and obtaining the extract in a suitable manner. The thick extract thus prepared contains theobromine, and it is intented for use either alone or as an addition to cacao powder and chocolate.

Strohschein in Berlin***) prepares from the cacao husks a thick liquid extract which he calls "Martol" Its preparation was suggested by the fact that cacao husk gives evidence of containing a considerable amount of iron. In "Martol" the iron is in the form of a tannate; in addition to this, the preparation contains theobromine, carbohydrates, and phosphoric acid. The preparation is said to be used as a medicinal remedy in chlorosis.

Alfred Michel of Eilenburg†) utilises cacao husks for preparing a brown colouring material. The husks, free from impurities, are first soaked in soft water with or without the addition of sulphuric acid, then washed and finally treated with a strong, 35 percent, solution of caustic soda. From the alkaline solution, the colouring matter is precipitated with and acid or acid metallic salt, collected on a filter and washed free from acid. Thus obtained it is a dark brownish red paste which, when dried, forms a blackish brown mass with a vitreous fracture. The yield of colouring matter is from 20 to 25 percent of the weight of the husks. The paste by re-treatment with alkali can be again obtained in solution and can be used as required in a liquid or pasty form. The colouring matter can be obtained of different tints either by soaking the husks in more or less dilute sulphuric acid or by precipitation from the alkaline solution at various temperatures; by addition of metallic oxides also more or less varied tints may be obtained.

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*) German Patent No. 71 373, 8. January 1873.

**) English Patent No. 14 624, 16. June 1897.

***) Pharm. Rundschau 1898, p. 781.

†) Zeitschr. für chem. Industrie 1878, p. 303. German Patent No. 2112. 24. Sept. 1878.

Briquettes according to Boussignault have been made in Paris from cacao husks, and 13 years ago we proposed to use them as cattle food, especially for horses. Experiments to that end were also instituted, but for several reasons they had to be abandoned. The question as to a rational utilization of the husks is once more receiving attention especially since the publication of the prize essay of the „Verband Deutscher Schokoladefabrikanten". The fodder value of the husks as determined by Märcker is apparent from the following figures:

	Free from dust	Fine meal	Dusty
	%	%	%
Moisture	9·08	6·50	9·95
Albumin	13·56	14·13	12·69
Digestible albumin	6·06	7·07	4·38
Fat	2·65	6·76	3·96
Fibre	29·14	25·80	21·55
Ash	6·32	6·44	7·26
Non-nitrogenous extractive	39·25	40·37	44·59

Feeding experiments which were carried out in certain agricultural institutes showed that cacao husk stands in nutritive value between good meadow hay and wheaten bran and is not only a fattening fodder for oxen but also a valuable feeding material for cows and deer.*) These results have been confirmed by Prof. Ferruccio Faelli in Turin.**) The advantages of cacao husks as a fodder over bran are apparent. 2 Centners (about 220 lbs avoirdupois) cost only about 6 to 7 shillings, whilst the price of bran varies between 9½ shillings and 12 shillings. Moreover the husks keep better, for after having been stored 18 months Professor Faelli found that they had undergone no alteration whilst on the other hand bran had become sour. A further advantage possessed by the husk is that it will absorb four times its weight of water against three times absorbed by bran. Cattle not only readily get accustomed to the fodder but subsequently take to it with eagerness. The best results were obtained with Dutch, Swiss and Parmesan milch cows. After 10 days feeding the butter and milk-sugar had increased, as well as the daily average yield of milk from 44 to 49·5 kilogrammes. As soon as the feeding with cacao husk was discontinued the yield of milk decreased. Faelli concludes that cacao husk, which can be used as a fodder up to 4 kilog. daily, exercises a very favourable influence on milch cows, and he purposes to continue the investigation with horses.

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*) Communication from the Verband Deutsch. Schokoladefabrikanten 1896 p. 32.

**) Quoted by Filsinger Zeitschr. f. öffentl. Chemie 1899 p. 27.

In a report on the Experimental Farms of Canada 1898, page 151, reference is made to the manurial value of the husks in enriching the soil with nitrogen and potash, a fact which had already been pointed out by Boussignault.

The future use of the husks appears therefore to be ensured, and it is to be hoped that it will allow of a permanent consumption of this bye product.

VIII. Ingredients used in the manufacture of chocolate.

Chocolate is a mixture of cacao mass with sugar, to which usually spices and even cacao butter are also added. The sugar generally amounts to rather more than one half (60 percent) of the mixture. Spices such as cinnamon, vanilla, cloves, nutmeg, mace, cardamoms, as well as cacao butter, or perfumes like peruvian balsam, are only added in small quantity so as to improve or alter the flavour as required. Recently, the ethereal oils of the spices have been used for this purpose as well as artificially prepared aromatic substances, such as vanillin for example. Flour and starch,*) although the latter is seldom used, are permissible ingredients in cheaper kinds of chocolate but only when the fact of the addition is plainly stated. The kinds of flour usually employed are wheat and potato flours, rice-starch and arrow-root, dextrin and, less frequently, oat, barley, acorn, chestnut, or rye flour. In certain forms of dietetic chocolate, as sugar is injurious to some invalids, sugar is replaced by saccharin; in that case, another material is employed in its place such as a leguminous flour from beans, peas or lentils.**) In some kinds of fancy chocolate, harmless colours, tincture of benzoin etc. are used.

1. Sugar.

Cane sugar as well as beet-root sugar are used in chocolate making. Chocolate being naturally of a brown colour, the cheaper semi-white kinds of sugar can be used as well as white sugar for mixing with the cacao mass. The kinds of sugar used are:

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*) Flour blends more easily than starch with the cacao mass as the granules of starch are with difficulty crushed.

**) Recently in some inferior kinds of cacao powder often some oatmeal has been added (up to 5 percent) which causes the preparation to thicken when it is boiled with water.

1. Sugar dust, a white crystallisable and very fine powder.
2. Sugar flour I, II, and III which is a difficultly cystallisable sugar containing an amount of molasses increasing with the number, and it is more or less of a brown colour.

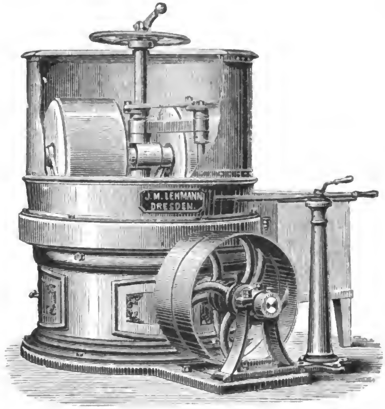

fig. 12.

The chocolate manufacturer nevertheless requires the sugar to answer to certain characters. It must dissolve in half its weight of warm water forming a sweet syrup. The syrup must have no action on litmus paper and on no account coagulate boiling milk.

The sugar is usually added to the cacao mass in the form of a very fine powder and sometimes in a coarser condition, though that is not to be recommended. By using finely powdered sugar, the rolling of the cacao mass is considerably facilitated and the manufacture is accelerated. The sugar must be perfectly dry, as damp sugar yields a dull chocolate which readily crumbles.

For grinding the sugar, the so called edge-runner mill as shown on figure 12 was formerly employed.

It is constructed of a firmly fixed bottom stone and two cylindrical runners, as in the mixer which will be described

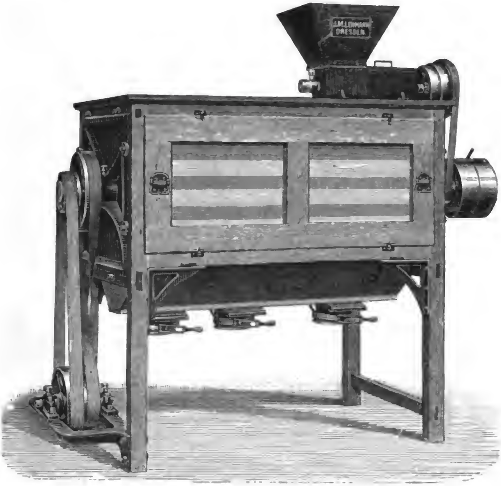

fig. 13.

later. As the upper part is surrounded by a mantel, the mill works quite free from dust. The machine can be emptied out whilst working with perfect safety since the mantel is furnished outside on the top with a handwheel for that purpose. Such a machine requires from 2 to 3 horse power and occupies a space of 1,5 cubic metre. From the edge runners the ground powder is carried through a so called paternoster work to sifting machines (chasseurs) usually placed at a higher elevation, one of which, known as the centrifugal-sifter constructed by J. M. Lehmann in Dresden, shown in fig. 13, answers all modern requirements.

In a slowly revolving cylindrical sifter, constructed of several separate frames, moves a rapidly revolving axle fitted with arms arranged as a screw. The whole is inclosed in a wood casing which is fitted at the lower part either with a carrying worm for removing the sifted material or with boxes for receiving it as shown in the drawing. The machine can also be fitted with lateral receptacles. The supply of sticky sub-

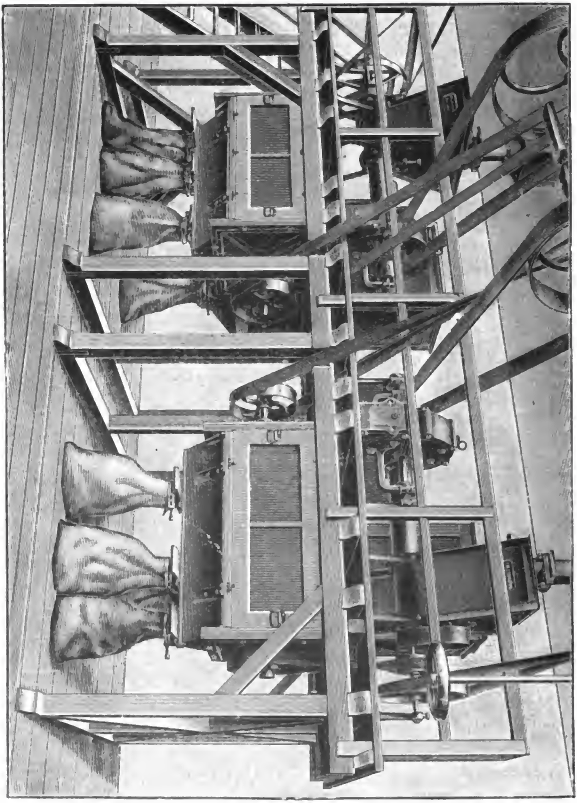

fig. 14.

stances, that are not easily worked, is provided for by a feeding apparatus fitted with stirrers which is shown in the drawing. The intervals between the frames of the sieve mantel are fitted up, according to requirement, wich silk ganze or brass wire-net.

In the working of this machine, the material operated upon is taken up by the blades of the axle and driven against the sieve mantel, so that the finer portions pass through the meshes of the sifting parts while the coarser portions fall out at the end of the machine.

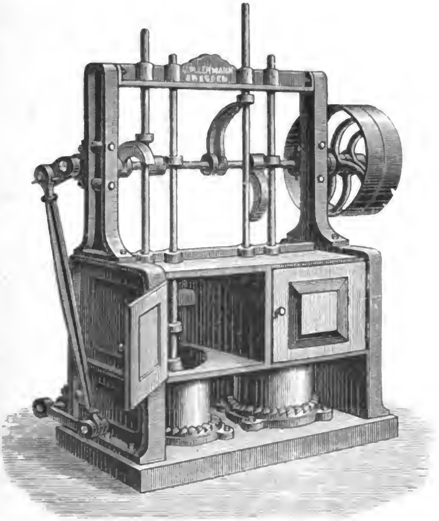

fig. 15.

The arrangements for grinding sugar have within recent years been very considerably perfected. One of the most rationally devised machines for grinding all kinds of crystal sugar etc. is the combined grinding and sifting apparatus made by Lehmann in Dresden. In that machine the grinding is effected by disintegrators, the working capacity of which is remarkably great; they yield a large quantity of product, and of a finer grain, the drier the material is that has to be ground. Such a machine is represented by fig. 14.

The axle fitted with blades makes 3000 revolutions in the minute. The sugar, brought by the feeding arrangement within the action of these blades, is caught up and driven against the walls of the mantel with such force that it falls as dust upon a grating of the sifting machine, through which the finer portion passes and the remaining coarser particles are again subjected to the same disintegrating action. The sifting arrangement consists essentially of a cylinder covered with silk gauze and fitted internally with revolving arms. By means of this machine and according to the nature of the sugar operated upon, from 1000 to 3000 kilos of dust sugar can be produced daily. The machine requires for that large result about 7 horse power.

The edge-runner mill and sifting machines above described are very well adapted not only for powdering sugar but also for grinding cacao that has been deprived of fat, as well as for grinding spices, but for the latter purpose other machines are generally used, such as the ball machine*) consisting of a hollow sphere revolving on its axis with a number of heavy metal balls inside, by which the material to be ground is crushed, torn, and reduced to powder. Sometimes other grinding mills or stamping works of the most varied construction are used for the purpose. The accompanying illustration fig. 15 represents a stamping mill constructed by Mr. J. M. Lehmann which is very useful for powdering all kinds of spices. It occupies a space 1650 mm long, 1000 mm broad and 2300 mm high; its gross weight is 1000 kilogrammes. The diameter of the fast and loose pulleys is 560 mm, each of them is 240 mm broad. The machine makes 60 revolutions and it requires $1^1/_2$ horse power to work it. The strong iron frame of the machine is so constructed as to be dust proof. While the stamps are being raised, the pots in which they work are turned on their axes so as to effect mixture of the materials.

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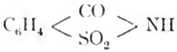
*) Very excellent machines of the kind are made with the newest appliances by the Krupp works at Magdeburg-Buckau.

2. Saccharin and other artificial sweetening materials.

In addition to sugar which is so important in chocolate making, another sweetening material must be mentioned which has recently been largely used as a substitute for sugar, namely saccharin, also termed zuckerin, sykorin, crystallose, "Süssstoff Höchst" and sykose.

Saccharin is not like sugar, a carbohydrate naturally produced by plants; but it is a derivative of the aromatic compounds which the chemist has artificially constructed from the products of the distillation of coal.

Saccharin is benzoyl-sulphonimide, and it has the chemical formula



$$C_6H_4 < \begin{matrix} CO \\ SO_2 \end{matrix} > NH$$

It is a white, tasteless, crystalline powder, so exceedingly sweet that its taste can be perceived in a dilution of 1 in 70,000. It is only slightly soluble in cold water (1:400) but is more easily soluble in hot water (1:28). The material known as easily soluble saccharin is the sodium salt; that contains 90 percent of saccharin and it is the most easily digested compound of saccharin.

For technical, domestic and medicinal purposes the soluble saccharin which is only from 300—450 times as sweet as sugar is employed. It is used in making bread, cakes, champagne, lemonade, mixed with oils, essences, and in medicines of all kinds. Besides being unfermentable saccharin has very slight antiseptic properties; according to L. Nencki*) the digestibility of albumin is less affected by it, in the proportion usually added to articles of food, than by Rhine wine, or by a sugar solution of equal sweetness. Saccharin is entirely unaltered in the human organism, hence it forms a welcome sweetening material for invalids suffering from diabetes, corpulence or diseases of the stomach to whom ordinary sugar is injurious. The substances known as dulcin and glucin are analogous to saccharin in sweetening property, the first being phenetol-carbamid and the latter a monosulphonate of amidotriazine.

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*) Chemiker-Zeitung 1899. Repert. No. 38. p. 372.

The latest substance of this class is named "sucramin". It is the ammonium salt of saccharin. It is readily soluble in water, less so in alcohol and is 700 times sweeter than sugar. It can be obtained either in the pure form or mixed (20 percent) with sugar.

In chocolate making, saccharin at present is of little importance owing to the relatively small volume required as compared with sugar. Recently it has again been recommended*) to the extent of 0,76 percent as a sweetening material for cacao powder. It would certainly fulfil a purpose in a cacao powder to be consumed by invalids. The detection of saccharin has acquired practical importance since the introduction in some countries, Germany included, of statutory regulations affecting the trade in artificial sweetening materials. According to the author's experiments, it can be detected in the following manner. A mixture of 5 grammes of the finely powdered substance with 100 ccm of water is allowed to stand for two hours with frequent agitation and then filtered. The filtrate is acidulated with three drops of hydrochloric acid and evaporated to 20 ccm, then shaken with 50 ccm of ether in a separator and allowed to stand for a day to separate into two layers. The ethereal solution is separated and evaporated to dryness in a beaker; the residue is then mixed with 0,10 gramme of resorcin and 4—5 drops of concentrated sulphuric acid,**) (Börnstein's test.) The mixture is then heated over a small Bunsen flame and the melted material saturated with normal sodium hydrate. The appearance of a strong fluorescence indicates the presence of saccharin. Saccharin can also be easily recognized by the sweet taste of the ether residue.

3. Starch etc.

The chief kinds of starch used in chocolate making are, rice starch, arrowroot, as well as potato starch and wheat starch; sometimes also a small quantity of dextrin.

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*) Chemiker-Zeitung 1889, p. 408.

**) Beckurts Jahresbericht über die Fortschritte in der Pharmacie etc. 1888 p. 307.

Potato starch or flour.

Potato starch is a white or faintly yellowish powder in which single, glistening granules can be seen by the naked eye. Under the microscope the granules appear mostly single with evident striæ, usually with pointed ends containing the nucleus; they are also eccentric in structure. This starch rarely contains fragments of tissue. It is prepared by treating finely divided peeled potatoes with dilute 1 percent sulphuric acid, then washing, drying and grinding the starch.

Wheat starch.

Wheat starch can be obtained either from crushed wheat or from wheaten flour by treatment with water after the nitrogenous constituent, gluten, has been separated by kneading. It amounts to about 60—70 percent of the grain. Under the microscope the granules appear to differ considerably in size. They are distinguished from potato starch by the nearly central hilum, surrounded by faintly marked concentric striae and by the granules being more frequently adherent. Wheat flour rather than the starch is generally used in chocolate making.

Dextrin.

When starch is heated to between 200° and 210° C. it is converted chiefly into dextrin or starch gum with a little sugar. Dextrin is a white to yellowish and tasteless powder with a peculiar smell; it differs from starch in being readily soluble in water. It gives a reddish colour with an aqueous solution of iodine. Fehling's solution is unaffected by dextrin in the cold, but on long continued heating it is reduced to the red cuprous oxide.

Rice starch.

Rice starch is obtained from inferior kinds of rice and from rice waste by treatment with water. It appears under the microscope as small granules or oval bodies of various sizes. According to their position the granules always seem to be polygons,*) formed by coalescence. It is thus easily distinguished from the previously mentioned starches.

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*) See Möller p. 114.

Arrowroot.

Several kinds of starch, obtained from the tubers of various species of plants are commercially known under this name.

1. West Indian arrowroot, from Maranta arundinacea, is a fine and almost white powder. Under the microscope it always appears to consist of pear or spindle shaped granules with eccentric hilum.

2. East Indian arrowroot is obtained from various species of Ginger-plants. It is a fine white powder and is seen under the microscope as single granules with well marked eccentric hilum and closely stratified at the spindle shaped ends. It much resembles Guiana arrowroot which is obtained from varieties of Yam.

3. Queensland arrowroot from species of Cycas and Canna, appears as flat, coarse and mostly single granules. They can be easily distinguished from other kinds of starch by the large size of the granules.

4. Brazil arrowroot, from the Manihot plants which belong to the order of Euphorbiaceæ. Under the microscope the granules appear compound; the parts being of a drum or sugar-loaf shape with many concentric striae.

Chestnut meal.

Chestnut or maron meal also comes under consideration in the chocolate industry. The appearance of the starch granules is most characteristic. They are partly single and partly composed of two individual granules. The single granules according to J. F. Hanausek*) appear in such a variety of forms as to defy a summarized description. Frequently they occur oval, spindle, club, or flat kidney shaped, resembling those of the leguminous family; but especially to be noticed is the triangular contour of some granules, as well as some with projecting points. The central nucleus and its cavity are generally distinct, but the stratification is very slight or quite unrecognizable.

Bean meal.

Of the leguminous meals that of beans is chiefly used as an adjunct in cacao powders and chocolate, sweetened with saccharin, on account of its relatively large proportion of albuminous substance and small amount of starch. The meal is generally obtained from the seed of the common white bean. (Phaseolus vulgaris.) The starch granules under the microscope appear oval or long kidney shaped, with distinct nucleus cavities and furrows, as well as a distinctly marked stratification. Their length averages from 0,033 to 0,05 mm. The meal has a disagreeable leguminous taste when cooked, but that disappears when the meal is slightly roasted.

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*) Die Nahrungs- und Genussmittel aus dem Pflanzenreiche p. 140.

Salep.

Salep which is now very seldom used as an admixture to chocolate (Rakahout of the Arabs)*) is an amylaceous powder prepared from the tubers of various kinds of orchids. Under the microscope salep appears as fairly large translucent masses which consist of an agglomeration of very delicate walled cells giving the starch reaction with iodine.

4. Vanilla.

Only the most important features of the spice so valuable in chocolate making will be noticed, since the characteristic aroma of the true vanilla has been, to a very large extent supplanted in practice by artificially prepared vanillin.

Vanilla is the fruit capsule of an orchid, Vanilla planifolia, which is generally cultivated with the cacao tree, as the same climate and soil suit them equally. According to Möller the shoots of the vanilla are fastened to the cacao tree, on the bark of which they soon strike root. The aerial roots and tendrils, then put forth fleshy leaves, in the axils of which arise large odourless and dull coloured flowers which yield after two years, long thin capsules. The capsules are filled with a transparent balsam, in which the black seeds are imbedded. It is in the balsam that vanillin is produced which gives the agreeable aroma to vanilla. The fresh gathered vanilla fruit according to the investigation of W. Busse**) contains no free vanillin or merely an infinitesimal quantity.

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*) This consists of 15 parts of defatted cacao, 200 parts of arrowroot, 50 parts of salep and fifty parts vanilla-sugar.

**) Arbeiten des kaiserl. Gesundheitsamtes Vol. 15 p. 1—113 and Zeits. f. d. Untersuch. von Nahrungs- und Genussmitteln Vol. 3. 21.—25. January.

It is developed by subsequent treatment in which heat appears to be necessary. Vanillin, like cacao-red and theobromine, is formed by the splitting up of a glucoside by fermentative action. In some kinds of vanilla, piperonal, an aromatic body, which occurs in larger quantities in Heliotropium europaeum and peruvianum, has also been observed.

The commercial kinds of vanilla come from Mexico, Tahiti, Réunion, Mauritius, Mayotte, Seychelles, Ceylon, and from Java which in 1891 produced respectively:

Réunion (Bourbon)	50—65,000	kilos
Mexico	55,000	„
Mauritius	13—15,000	„
Mayotte (Comoro islands)	8—10,000	„
Seychelles	4— 6,000	„

The best commercial kinds of vanilla come from Mexico, Bourbon, and Mauritius; they command a higher price than the other kinds. The quantity is gauged by the length (10—24 cm), and plumpness of the pods. Fine quality is fatty and dark coloured, inferior quality is dry and reddish. The outside of the pods in the valuable Bourbon vanilla, contains vanillin crystals, which are wanting in the Mexican variety. Vanilla flowers in October and November, is gathered in the following months of May, June, and July, and is prepared in October and November. At the beginning of November the first instalment of the new harvest arrives in Marseilles which is the chief commercial place for vanilla. The most important operation, in preparing vanilla, is to attain the proper degree of dryness. This is arrived at nowadays by the use of calcium chloride. The pods are first placed in a wool lined metallic box which is placed in warm water so as to superficially dry them; they are then transferred to a suitably constructed drying closet containing calcium chloride and allowed to remain there for 20—30 days. 100 pounds of vanilla are reckoned to require 40 pounds of calcium chloride. The great advantage of this process is that the fruit, so dried, better retains the aroma.*) Insufficiently dried vanilla does not keep, but soon becomes mouldy, whilst overheated vanilla keeps well, but is brittle, breaks easily and consequently has little commercial value. Vanilla covered with mould (Aspergillus repens and Mucor circinelloides) is sought to be improved in various ways and is sold as of inferior quality.*) It is worth observing that those persons who in the course of business handle vanilla show characteristic symptoms of poisoning. It affects the eyes and nervous system and produces eruptions on the skin. The complaint, however, is not of a dangerous nature, for the workmen quickly become accustomed to vanilla so that, after recovery from the first attack, they can resume work without risk to health.**)

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*) Der Tropenpflanzer 1898, p. 24.

On account of its high price, vanilla is much subjected to adulteration; either by an admixture of the more cumarin-smelling vanillon (Pompona or La Guayra-Vanilla [Vanilla Pompona Schieder]) or other less valuable vanilla fruit; sometimes pods that have been deprived of vanillin by extraction with alcohol are used for that purpose; their colour and appearance being restored by immersion in tincture of benzoin and coating with crystals of benzoic acid, powdered glass etc. In doubtful cases of adulteration the vanillin must be quantitatively determined. That can be done by W. Busse's method***) in which the vanilla is extracted with ether in a Soxhlet's apparatus. The extract is shaken with a solution of sodium bisulphite, the vanillin then set free with sulphuric acid and the disengaged sulphurous acid removed by a stream of carbon dioxide. The vanillin is then shaken out with ether and on evaporating off the ether, vanillin is left in a pure condition. Busse found by this method in East African vanilla 2·10 percent, of vanillin, in the Ceylon 1·48 percent, and in the Tahiti variety from 1·55 to 2·02 percent. In America the so called vanilla extract, instead of vanilla, is used and it lends itself to adulteration much more easily than natural vanilla. William Hesse has given methods and results obtained in the investigation of the extract.†)

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*) Journal of the Society of Arts 1897. Vol. 46. p. 39—40.

**) Compare Gieseler, Vanillevergiftungen. Bonn 1896; Arning (Deutsch. med. Wochenschrift 1897, pag. 435) and Guerin (Annales d'occulistique, 1895 v. 4. Oçtober).

***) Arbeiten aus dem Kaiserl. Gesundheitsamte 1899.

†) Journal of the American Chem. Society 1899. Vol. 21. p. 719 and Chem. Ztg. Rep. 1899. p. 275.

5. Vanillin.

Vanilla in the chocolate industry has recently been almost entirely superseded by the use of artificially prepared vanillin which serves as a complete substitute for the essential and valuable constituent of vanilla. In comparing vanillin with vanilla, regard must be had to the amount of vanillin in the latter, which may vary to the extent of 50 percent according to whether the vanilla was damp, dry, fresh or stored. The finest kinds of vanilla seldom contain more than 2 percent of vanillin and in many kinds it varies between 0,5 and 2,5 percent. It may also happen that vanilla with 0,5 to 1,0 percent may be equally as fine in appearance as one of high percentage, hence the aroma value must be taken into consideration. In addition to possessing a uniform and permanent perfume vanillin is cheaper in price.

Vanillin occurs naturally not only in vanilla but also in very small amount in certain kinds of raw sugar, in potato skins and in Siam benzoin; it can be produced artificially from coniferin which is obtained from pine wood, or by the oxidation of eugenol, a substance contained in oil of cloves from both of which Tiemann and W. Haarmann*) first prepared it in 1872. In the course of the last ten years a number of processes have been discovered whereby vanillin can be artificially produced. The reader who is interested in this subject will find it fully discussed in a paper by J. Altschul in No. 51 of the Pharmazeutische Centralhalle 1895.

The competition which arose through the processes of Haarmann and Reimer of Holzminden and G. de Laire of Paris, whose products owing to patent rights had controlled the market from the commencement, produced a steady decrease in the price of vanillin.

The following table drawn up by J. Rouché**) shows the revolution in price which has occured in this article and how, in the course of time, a small business with large profits has been transformed into a large business with small profits.

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*) Berichte der deutschen chemischen Gesellschaft Vol. VII p. 698 and Friedländer, Fortsch. der Theefarbenfabrikation. Berlin 1888. p. 583 and elsewhere.

**) L'état actuel de l'industrie de la parfumerie en France. Revue générale des sciences pures et appliquées. Paris 1897, p. 663.

The variation in the price of vanillin:
Marks per kilo.

1876	1877	1878	1879	1881	1882	1884	1885	1886	1888	1890	1892	1893	1895	1897
7000	4000	2400	1600	1600	1600	900	900	700	700	700	700	700	560	108

The chemical formula of vanillin is $C_6H_3(OCH_3)(OH)CHO$; it melts between 82—83° C. and sublimes at 120° C. The colourless foursided crystals have a strong vanilla odour and taste, are difficultly soluble in cold water, easily in hot water and very readily soluble in alcohol.

Vanillin is much adulterated. Cumarin the aromatic principle of the melitot (meliotus officinalis), of tonquin beans etc., can be prepared cheaply and it is fraudulently used in large or small quantity to imitate the vanillin aroma. A sample of vanillin bought in Switzerland was found by Hefelmann*) to contain 26 percent of antifebrin. The American "vanilla crystals" consist of a mixture of vanillin and antifebrin, or vanillin, cumarin and benzoic acid; latterly that article is stated to consist only of cumarin, antifebrin and sugar.

The melting point of genuine vanillin is a characteristic indication. Admixtures of vanillic acid and antifebrin cause depression of the melting point (4—8° C. according to the amount and character of the two substances [Welmans]**). For the quantitative determination of vanillin in mixtures, Welmans takes advantage of its behaviour towards caustic alkalies with which, like phenol, it forms compounds that are easily soluble in water, but sparingly soluble in alcohol. The process is as follows: 1 gramme of the substance is placed in a cylinder of 200 ccm capacity with 25 ccm of alcohol, 25 ccm of approximately seminormal alcoholic potash and 2 or 3 drops of phenolphtaleïn solution and agitated until completely dissolved. The excess of alkali is then titrated with seminormal hydrochloric acid, and, at the same time, the strength of the alcoholic potash after adding 25 ccm of alcohol is ascertained. The number of cubic centimetres consumed is multiplied by 0,076 the semifactor for vanillin. In the case of vanilla sugar 10 grammes are treated with 50 ccm of water to dissolve the sugar, then the alcoholic potash is added and the operation carried out as before described.

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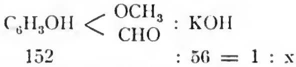
*) Chem. Zeit. Repert. 1898, p. 181.

**) Pharm. Zeit. 1888 p. 634 and Pharm. Centralhalle 1898, p. 673.

1 gramme of vanillin requires 6·58 ccm of normal potash (= 0·36842 g KOH).



$$\begin{array}{lcl} C_6H_3OH < \begin{matrix} OCH_3 \\ CHO \end{matrix} & : & KOH \\ 152 & : & 56 = 1 : x \end{array}$$

If cumarin is suspected to have been added to the vanillin it can be detected and separated, according to my experiments, by the method of W. H. Hess and A. B. Prescott.*) The substance is dissolved in ether and the solution shaken up with a weak solution of ammonia. The vanillin will be found in the aqueous layer in the form of an ammonium compound whilst the cumarin will be dissolved by the ether. The vanillin can be identified by the sandal-wood oil reaction as described by Bonnema,**) and the cumarin can be determined by direct weighing.

The financial advantage in using vanillin in place of vanilla is apparent. The average price of vanilla is now 60 to 70 shillings per kilo. But as 25 grammes of vanillin are equal in perfume to 1 kilo of vanilla and, at the rate of 108 shillings per kilo, that quantity costs only 2 sh. 9 d., vanilla is nearly twenty times dearer than vanillin. The consumption of vanillin has increased to an enormous extent, and in the United States Henning has estimated the consumption during 1897—1898 at over 100 000 ounces. The same author points out the remarkable fact that this enormous consumption of vanillin has scarcely any effect on the demand for vanilla pods, the market value of which is not only maintained but has a tendency to increase.

In order to have vanillin in a finely divided condition as required in factory work it is recommended to rub the vanillin down with sugar, in the proportion of 100 grammes of vanillin to 2 kilos of sugar, in the following manner; 100 grammes of vanillin are dissolved in 500 grammes of hot alcohol and this solution added to 2 kilos of finely powdered sugar then the whole is placed in a rotatory comfit boiler and dried by a blast of warm air at 40° C. Whilst vanilla must be very carefully packed that it may not become mildewed and deteriorate, vanillin on the other hand keeps very well in such mixtures, so long as they are kept from damp which might cause the sugar to ferment and thus gradually decompose the vanillin.

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*) Zeitschr. für angewandte Chemie 1899, p. 428.

**) Pharmaceutische Centralhalle 1898, p. 357.

6. Cinnamon.

There are three commercial kinds of cinnamon in Europe.

1. Ceylon cinnamon, which represents the finest kind, is the bark of Cinnamomum ceylanicum, a native of the island of Ceylon. The bark is very light and brittle, seldom more than 0,5 mm thick, externally yellowish brown with long stripes, whilst it is somewhat darker on the inside. Its fracture is short and fibrous, and a traverse section shows externally a sharply defined light colour with a darker inside zone.

2. Cassia or Chinese cinnamon is from Cinnamomum Cassia, a tree which grows wild in the forests of Southern China. The bark is thicker than that previously described, often 2 mm thick. It is in single tubes which are harder and thicker than the Ceylon kind and frequently have adherent fragmentary tissues of the corky layer. The colour is greyish brown, the fracture even, with a light zone in the section.

3. Malabar or wood cinnamon consists of the less valuable kinds and is derived from different varieties of cinnamon trees which have been planted in the Sunda and Phillipine islands. In appearance it resembles the Chinese more than the Ceylon cinnamon.

The aromatic taste of cinnamon is due to the ethereal cinnamon oil which, in Ceylon cinnamon, amounts to 1 percent; the ash should not exceed 4—5 percent. An ethereal oil is also present (about 1—8 percent) in the leaves of the Ceylon cinnamon tree but it is quite different from the bark oil, resembling in its properties more the oils of cloves and pimento. On account of its penetrating odour and pungent taste its employment in chocolate making is little to be recommended.

It cannot be too much insisted on that with spices like cinnamon, cloves, etc. the manufacturer should grind them himself and not purchase them in fine powder, as the latter is frequently adulterated with admixtures of wood, meal, bark, etc. This is more to be recommended as ground cinnamon has frequently been deprived of the ethereal oil by distillation with steam and the bark then flavoured with a small amount of cinnamon oil and sold as powdered cinnamon. Such an adulteration can be detected neither chemically nor microscopically.

7. Cloves.

Cloves are the incompletely developed flowers of the clove tree, Caryophyllus aromaticus of the Myrtaceæ. The most important commercial kinds are the Zanzibar, Amboyna, and Penang cloves. The aromatic principle of cloves is an ethereal oil which they contain to the extent of 18 percent. The adulteration of cloves is much the same as in the case of cinnamon. Genuine cloves should not give more than 6 percent of ash.

8. Nutmeg and Mace.

Nutmeg is the seed kernel of the fruit of Myristica moschata known as the nutmeg tree, which is indigenous to Malacca. In the thick pericarp of the fruit, resembling the apricot, is found the brown seed surrounded by a deep red reticular mantle. This last is the seed mantle or arillus and when separated from the kernel is known commercially as mace. The furrows on the surface of the nutty seeds are filled with a white mass which consists of lime in which the nuts have been laid after drying in order to protect them from the attack of insects. The aromatic constituent of nutmeg and of mace is also an ethereal oil. The seeds contain 8—15 percent of ethereal oil with 25 percent of a fatty oil; mace contains 4—15 percent ethereal oil and 18 percent fatty oil. As both spices occur in commerce in whole pieces adulteration is not to be feared.

9. Cardamoms.

Of these are two kinds in the market:

1. The small or Malabar cardamoms.
2. The long or Ceylon cardamoms.

Both are the fruit, although very different in form, of a species of the ginger plants which is indigenous to Ceylon and Malabar.

The Malabar cardamom is three cornered and oblong about

1 cm in size. In the fine brown pericarps are enclosed, adhering together, 6—8 angular seeds, 3 mm in size, having a pungent aromatic taste.

The Ceylon cardamom is four times larger than the Malabar kind. The grey brown pericarp encloses about 20 dark greyish brown seeds about 6 mm large. The aroma of the Ceylon cardamom is due to an ethereal oil of which it contains up to 6 percent. Madras and Malabar cardamoms contain 4—8 percent ethereal oil. As the Ceylon cardamoms are cheaper than the Malabar kind a confusion of the two seeds might possibly be to the disadvantage of the buyer, but the above description of their relative size would suffice to distinguish them.

Exact accounts of the characteristic properties, the chemical and microscopical investigation as well as of the impurities and adulterations of the materials previously mentioned as being used in cacao preparations are to be found in volume II of the "Vereinbarungen zur einheitlichen Untersuchung und Beurteilung von Nahrungs- und Genussmitteln sowie Gebrauchsgegenständen für das Deutsche Reich" to which those who desire further to investigate this subject are referred.

10. Ethereal oils.

As previously remarked in the case of vanillin it is becoming more and more the custom to substitute perfume substances for powdered spices. This practice is quite justified since the entire perfume of a spice is made use of and the worthless woody and indigestible fibre is thus excluded from the finished preparation.

The following are the ethereal oils used in practice:

Cinnamon oil,
Clove oil,
Cardamom oil,
Coriander oil,
Nutmeg oil (ethereal),
Mace oil (ethereal).

The amount of ethereal oil that should be used in place of the corresponding spice is a matter of taste. The maximum percentage of the oil in the respective spice might serve as a standard, as for example in the case of cinnamon oil, which is contained in the bark to the extent of 1 percent, about $^1/_{100}$ th part of the oil would be required to correspond with the prescribed weight of the bark. But as the yield of oil from one and the same kind of spice varies to a considerable extent according to season and locality, the percentage value can only be used as a general guide, and the final decision must be always regulated by the taste.

The ethereal oils can be incorporated in the cacao preparations (mass, powder etc.) either in a spirit solution or rubbed down with sugar. The latter method is naturally only used when sugar is to be added to cacao preparations. To prepare the alcoholic solution 10 parts of the ethereal oil are dissolved in 90 parts of strong alcohol. The mixture of oil with sugar can be made by triturating 2,5 parts of the ethereal oil with 100 parts of sugar in a porcelain mortar and rubbing down with the pestle until the sugar and oil are intimately mixed. Of the alcoholic solution it is necessary to take 10 parts, and of the oil-sugar 40 parts to equal one part of ethereal oil.

For some years past the Hamburg firm of James R. Mac Donald & Co. have brought into commerce under the name of "Theobrominat" a liquid which is stated to improve the aroma of cacao and to confer upon the inferior kinds (Thomé etc.) the aroma of Guayaquil cacao. "Theobrominat" is especially introduced for use by English and Dutch makers in all cheap products, and even Guayaquil preparations; only the dearer kinds of cacao like Porto Cabello and Caracas are to be excepted, in which cases their particular aroma is to be preserved.

According to a statement of the makers, theobrominat should be sprinkled on the cacao beans before they are placed in the mixer (3 tea spoonsful to 100 pounds) in making the cacao mass; in making cacao powder it is again sprinkled on the pressed cake during the grinding by the edge runners. In the preparation of cheap chocolates and coatings the materials otherwise already flavoured with aromatic substances are to be treated with "theobrominat" just before moulding. For "Suppenpulver"*) theobrominat is to be added by the tea spoonful. From the investigation of the Leipzig firm of spoonful. From the investigation of the Leipzig firm of Schimmel & Co. whose accuracy is undoubted, theobrominat which costs 32 shillings per kilo is nothing more than a 15 percent spirituous solution of coriander oil, which could be prepared with the greatest ease for one third of the cost by simply mixing 150 grammes of coriander oil with 850 grammes of spirit.

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*) A mixture of cacao, sugar, wheaten flour and powdered spices.

11. Peru balsam and Gum benzoin.

Peru balsam is at present very much used as a perfume in chocolate making. It is obtained from the Papilionaceous Myroxylon Pereira which is indigenous to the western part of Central America. It is a thick, brownish -black, liquid balsam which in thin layers appears transparent and has a peculiar smell and burning taste; it is almost completely soluble in alcohol, chloroform, and acetic ether. The aromatic substance of this balsam is cinnameïn which consists essentially of the esters of benzoic and cinnamic acids and benzyl alcohol together with an alcoholic body "Peruviol", which has the smell of honey. In addition to cinnameïn (71—77 percent) the balsam also contains a resin ester (13—17 percent). According to K. Dieterich, Peru balsam is the better for containing more cinnameïn and less resin ester. Peru balsam is adulterated with fatty oils, copaiva, gurjun-balsam, storax, colophony, turpentine, and tolu balsam. In regard to the chemical investigation of this balsam the work of K. Dieterich*) may be consulted.

The Sumatra benzoin is the most important of the commercial kinds for chocolate making. It is obtained from one of the Styraceæ, Styrax benzoin, and is a reddish grey mass in which separate tears of resin are embedded. Benzoic acid and vanillin are the most important constituents. It is adulterated with Palembang benzoin, colophony, dammar, storax, and turpentine. Respecting the chemical investigation of commercial benzoin the above mentioned work of K. Dieterich may also be referred to.

Benzoin is almost exclusively used for the preparation of chocolate varnish and confiture lac which are prepared by dissolving from 25 to 45 grammes of the lac body in 100 grammes of strong spirit. The lac body may contain varying quantities of benzoin and bleached shellac. The decorations of chocolate are painted with this lac in order to give a glistening appearance and greater durability.

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*) K. Dieterich, Die Analyse der Harze, Balsame und Gummiharze. Berlin 1900, page 76.

12. Colouring materials.

The following colouring materials are permitted by the German law of the 14. May 1879 to be used for sugar goods and consequently also for chocolate and cacao preparations.

White: finest flour starch.

Yellow: saffron, safflower, turmeric.

Blue: litmus, indigo solution.

Green: spinach juice as well as mixtures of the permitted blue and yellow colours.

Red: carmine, cochineal, madder red.

Violet: mixtures of the harmless blue and red colours.

Brown: burnt sugar, licorice juice.

Black: chinese ink.

In the mean time a number of comparatively harmless aniline colours have been permitted in Austria for colouring sugar goods and liqueurs, and eventually also for cacao preparations.*) As in the author's opinion there is no ground for objecting to their use in other countries, a list of them is given under their commercial and scientific designations.

Red:

Fuchsin = Rosaniline hydrochloride, soluble in water and alcohol.

Acid Fuchsin or Fuchsin S or Rubin = Sodium or calcium acid salt of rosaniline disulphonic acid, soluble in water.

Roccellin or Roscellin (Fast Red) = Sulpho oxyazonaphtalin, soluble in water.

Bordeaux and Ponceau red = product of the combination of β naphtol-disulphonic acid with diazo-compounds of Xylol and higher homologues of benzol, soluble in water.

Eosin = Tetrabrom-fluoresceïn, soluble in water and alcohol.

Phloxin = Tetrabromo-dichlor-fluoresceïn, soluble in water.

Erythrosin = Tetra iodio-fluoresceïn, soluble in water.

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*) Regulation of 22 and January 1896.

Blue:

Alizarin blue = Dioxyanthraquinone-quinoline, slightly soluble in alcohol.

Aniline blue=Triphenylrosaniline, soluble in alcohol.

Water blue = Triphenylrosaniline, sulphonic acid soluble in water.

Induline = Azodiphenyl blue sulphonic acid and its derivatives, soluble in alcohol.

Yellow:

Acid yellow R or fast yellow R = Sodium amidoazobenzol-sulphonate, soluble in water.

Tropaeolin 000 or Orange I = Sulphoazobenzoll α-naphthol, soluble inw ater.

Naphthol yellow=Sodium salt of dinitro-α-naphthol sulphonic acid, soluble in water.

Violet:

Methylviolet = Hexa- and penta- methylpara-rosaniline hydrochloride, soluble in water and alcohol.

Green:

Malachite green = Tetramethyl-diamidotriphenyl-carbinol hydrochloride, soluble in water and alcohol.

For some time past E. Merck of Darmstadt has supplied a perfectly harmless green colouring material under the name of chlorophyll, in alcoholic and in water solutions, as well as technical chlorophyll, for colouring oils and fats, which is the unaltered leaf green and is the best green colouring agent for articles of food and therefore for cacao preparations.

The chlorophyll which is soluble in fat has also been recommended like some of the aniline colours which are soluble in fat, as for example: Indulin 6 B (blue), Sudan yellow G, Sudan III (red), and Gallocyanin (violet) for colouring cacao butter; but in regard at least to the aniline colours mentioned, no authoritative sanction for their use has yet been given.

Manufacture of Cacao preparations.

IX. Manufacture of Chocolate.

Preparation of the beans.

Up to the end of the 18th century the manufacture of chocolate was carried on entirely by hand on a small scale, and it was a very laborious operation. The beans were crushed in iron mortars, the workmen meanwhile kneeling on the ground; it was not until 1732, that Buisson*) introduced the use of a bench, by which that inconvenient and unwholesome practice was done away. At the present time, the Chinese cooks in the Philippine islands carry about with them the appliances they use in preparing chocolate from the cacao beans grown in those islands. They consist of a small marble mortar, in which the shelled beans are crushed by means of a warmed pestle, and of a board, on which the crushed mass is kneaded up with sugar and spices. With that exception hand labour has now been replaced entirely, in the manufacture of chocolate, by machinery. The first machine employed for the purpose was exhibited before the medical faculty at Paris in 1778 by Doret. According to Belfort de la Roque**) a Genoese named Bozelly constructed a mill by means of which he was able to prepare six or seven hundred pounds of chocolate daily, while the quantity that could be made in a day by hand, was not more than thirty pounds. In 1819 Pelletier***) described a machine, constructed by himself, that was capable of doing the work of seven men. Since that time, chocolate making machines have been variously improved, though in principle they have always been adapted to the purpose of reducing the cacao mass to an impalpable state of division and then intimately mixing it with various other substances.

The first modern machines for manufacturing chocolate have been employed in 1830 by the Paris mechanician George Hermann. At the present time a number of factories are engaged in the construction of machines for working up cacao, among the principals of which are the firms of J. M. Lehmann in Dresden-Löbtau, A. Savy & Cie. in Paris and J. Baker & Sons in London.

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*) See Mitscherlich p. 111.

**) Guide pratique de la Fabrication du Chocolat p. 112.

***) Comptes rendus de l'Exposition 1819, quoted by B. de la Roque.

However the manufacture of chocolate may be carried out, whether on a large or small scale, it always involves the same series of operations to which the cacao beans must successively be subjected in order to produce the article known in trade as chocolate. These operations are carried out in the following order:

1. Storing, cleansing and sorting the beans.
2. Roasting the cleansed beans.
3. Crushing, shelling and removing the radicles.
4. Mixing different kind of beans.
5. Grinding the beans until they yield a homogeneous pasty mass when warm.
6. The incorporation of the liquefied cacao mass with sugar and spices.
7. Trituration by rollers.
8. Extraction of air, division and moulding.
9. Cooling the finished chocolate.

1. Storing, cleansing, and sorting of the beans.

The raw cacao beans must be kept, up to the time they are to be used in the manufacture, in a spacious, airy magazine. If they have become moist during transport or in any way damaged in the harvesting, they must be turned out of the sacks, spread out on the floor of a well ventilated loft and frequently turned over with shovels. It has been recommended that damaged beans should be washed with a dilute solution of caustic potash (1 in 5000) and then rapidly dried.

The magazines in which cacao beans are stored have sometimes an unwelcome visitor — in the shape of a maggot, which according to W. Hauswaldt*) attacks the best kinds of Caracas as well as Trinidad. Since the eggs have been found in the interior of beans, that were still enclosed in the shell,

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*) Korrespondenz des Verbandes Deutsch. Schokoladefabrikanten 1878, p. 17.

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it may be inferred that they were deposited by a fly of unknown species either before or after the fermentation. Sometimes these maggots are found on the outside surfaces of the sacks over which they spread in a few days. Removal of the infected packages, opening the sacks and exposure to the sun as well as thorough cleansing of the storehouses may be of some service in such cases. The best plan is to destroy the moths during the month of June, July and August: that is effected best, according to Hauswaldt, Stollwerck,*) and G. Reinhardt,**) by placing in the store rooms large shallow basins of water with a small petroleum lamp near each, during the night, so as to be reflected on the surface of the water. The moths gather round the light and are then either burnt, or caught in the water: even the larvæ are attracted by the water and drowned. The water in the basins must be changed every day, otherwise the dust collecting on the surface enables the moths to escape. As the weather becomes colder, the windows of the store-rooms are left open day and night in order that any remaining maggots may be killed by frost.

The cleansing and sorting of cacao beans are important operations in connection with chocolate manufacture, because the possible use of cheaper kinds after having been thoroughly cleansed and sorted for mixture with those of better quality has a financial advantage. The chief object of cleansing and sorting is to remove foreign admixtures such as sand, stones, fragments of sacking, etc. which might damage the machinery in subsequent operations or communicate to the material objectionable characters. The admixtures are so various that their removal cannot be effected altogether by mechanical appliances.

Before describing the method of cleansing the raw beans it will be desirable to say something of the means by which the external appearance of the beans may be improved. Cacao that has not been fermented or that has not been well harvested, generally presents a grey, or greyish white to spotty brown, or clear violet colour in the cotyledons as well as a disagreeable astringent and bitter taste, those characters being communicated to the manufactured products and manifest themselves in a more or less objectionable manner. Attempts have been made to provide against that evil, by a treatment that is known as the after-fermentation, for which purpose, Gordian recommends that the beans should be digested with water for 48 hours and then dried at a temperature of 40°—50° C. By that treatment both the colour and taste are considerably improved.

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*) Korresp. d. Verbd. Deutsch. Schokoladefabrik. 1891. No. 5.

**) ibidem, 1891 No. 7.

The cleansing of the raw beans was formerly carried out in casks fitted on an axle running slantwise through the end of the casks, so that when revolving, the beans in the cask were rubbed together and foreign substances were removed, partly in that way or by subsequent hand picking; more recently rotatory cylindrical screens of various construction have been employed for the purpose, driven either by steam or water power.

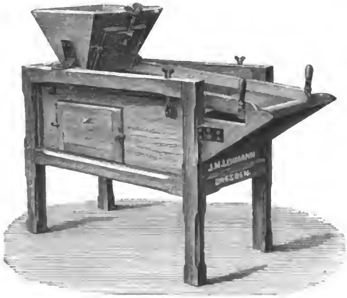

fig. 10.

The screen consists of a wooden case fitted with a revolving cylinder covered with wire gauze and fed with cacao beans from a hopper fixed above. While working, the cylinder is made to strike at intervals against the fixed casing, and meanwhile a current of air is driven through the cylinder, to carry away dust, while sand and stones are shaken out through the meshes of the wire gauze.

The partially cleansed beans are then transferred to another cylindrical screen, which sorts them in three sizes. The object of that operation is that in the roasting, the beans subjected to that treatment should be all nearly of the same size, so as to ensure uniform roasting. If beans of dissimilar size were treated, the larger ones would either be imperfectly roasted or the smaller ones would be overroasted.

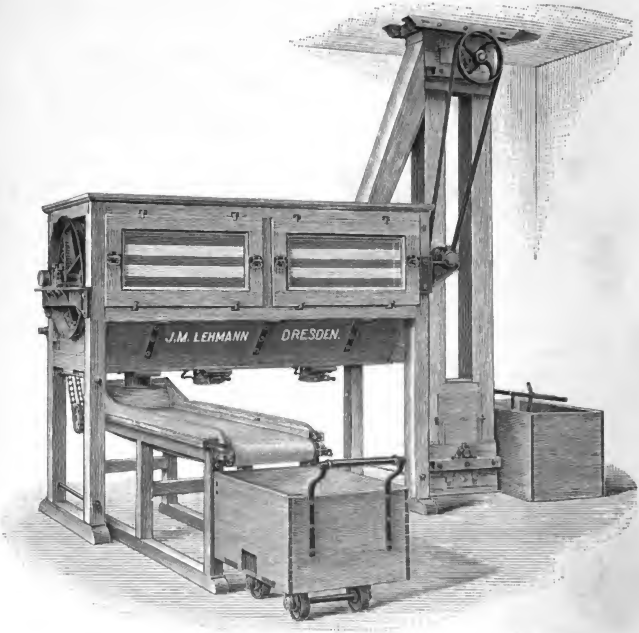

fig. 17.

After the beans have been passed through this screen, each portion is again hand picked and all worm eaten or otherwise damaged pieces are removed.

For the more convenient sorting of raw beans, Lehmann has constructed a machine to be worked by hand, and by means of which the beans are simultaneously freed from dust.

This machine is represented by fig. 16, it is 1400 mm long, 600 mm broad and 1200 mm high, its weight is 110 kilos.

For operations on the large scale, the cleansing and sorting machines of J. M. Lehmann represented by fig. 17 are more suitable. They require a driving power of one horse; the beans are fed in by an elevator, and they are freed from dust and grit by passing along a cylindrical screen, within the wood casing, finally falling out upon a travelling band where they are picked over by hand and any foreign substances or defective beans are removed. With this machine two girls can pick from 40 to 50 cwt. of beans a day.

This machine can also be worked with two travelling bands running on opposite sides. The receivers are fitted on wheels, lined with zinc, the bottom is sloping and there is at one side a sliding shutter. A similar machine is made for work on a smaller scale, without an elevator, which requires 0,3 horse power.

2. The roasting of the beans.

The cleansed and sorted beans are exposed to heat and thus roasted.

The object of roasting is manifold:

1. By that means the aroma is developed;

2. The starch granules are gelatinized;

3. The astringent tasting constituent of the bean is so far altered, that the taste of the bean is improved;

4. By the consequent drying, the husk or shell of the bean is rendered brittle and more easily removable, while the beans become friable.

At the commencement of the last century the shells were separated from cacao beans by the Weisched method*) of stirring the beans in water until the seed membrane became removable and then heating the beans sharply until the husks broke off.

That method is now only of historic interest and the roasting drum, similar to that used in roasting coffee, is now in general use.

The roasting may be carried out in the roasting drum in two ways:

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*) See Mitscherlich p. 112.

1. By direct or indirect exposure to a coal fire.
2. By gas with compressed air.

The cacao beans do not require for roasting a temperation so high as that applied in roasting coffee. Experience has shown that the above mentioned chemical and physical changes are brought about best at a temperature between 130—140° C.

In roasting over an open fire great care must be taken, so that the beans are neither too little roasted nor too much as in either case their value would be reduced.

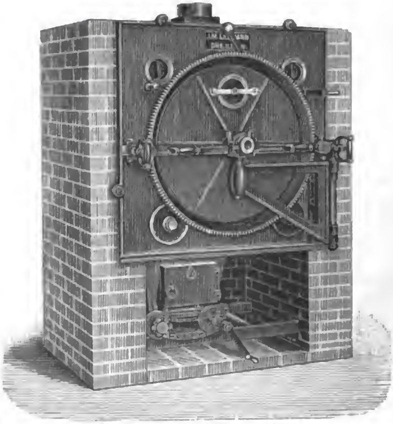

fig. 18.

The idea that the working of a roasting machine may be entrusted to any inexperienced workman is a very erroneous one. On the contrary, the recognition of the degree of roasting requisite for a particular kind of cacao, is an important point in regard to the quality of the chocolate made from it. Whatever is imperfectly done in the roasting operation, cannot possible be made up for afterwards by the most capable chocolate maker. For that reason the roasting operation is always carried out under the supervision of an experienced workman possessing the requisite faculties of taste and smell.

The point of over-roasting is indicated by the development of a disagreeable empyreumatic odour (like that of roasted coffee), the husks become charred, the kernels crumble and are superficially charred. There is also a correspondingly increased sharpness in the taste and, at the same time, a reduction in the amount of theobromine in the kernels, with an increased amount in the husks. The overheated cacao fat is partially converted into acroleïn which communicates to the overroasted beans its pungent empyreumatic smell.

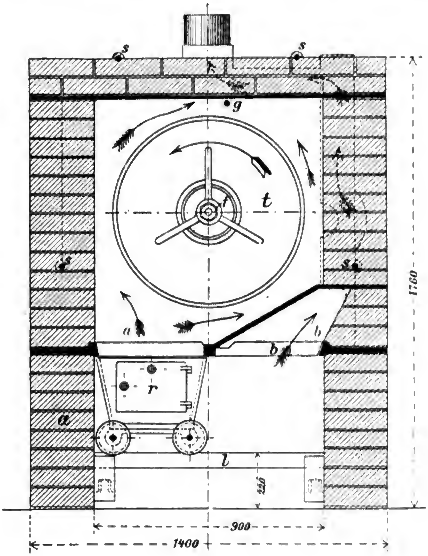

fig. 18a.

The general precautions to be observed in roasting cacao are: 1. That the beans should not remain too long in the roasting drum; 2. that they should be kept in constant agitation and for that reason the apparatus is made movable

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a) Course of the furnace-gas in direct firing.

b) Furnace-gas flue for indirect firing.

on its axis; 3. that the heat applied should be carefully regulated; 4. that the roasted beans should be rapidly cooled in order to prevent loss of aroma, caused by after-roasting.

The art of controlling the roasting operation in a particular apparatus must be learnt empirically by the person conducting it and it would be difficult to describe it from a theoretical point of view. It would be useless to prescribe definite instructions as to the duration of the roasting, or, as to the degree of heat to be applied, because both would be affected by the quantity of beans operated upon, by the greater or less draught of the fire, as well as by the kind of beans to be roasted.

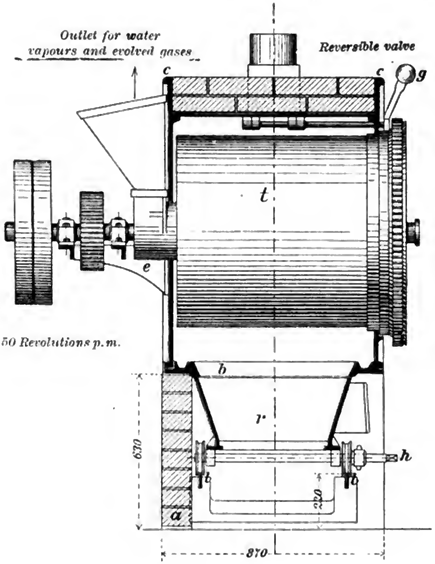

fig. 18b.

The accompanying illustration fig. 18 represents Lehmann's roasting apparatus which fulfils all the requirements of modern chocolate manufacture; Figs. 18a and 18b, showing the apparatus in section and with the brickwork setting removed, will render its construction intelligible.

The outlet from the furnace by which the heated gases escape when direct heat is applied is indicated by the arrows in fig. 18a. The heating is effected by the portable furnace r, situated below the drum and movable laterally, so that it can be shifted on one side, when the drum ceases to revolve, for the purpose of charging or emptying the roaster. The charging is effected through a casing fitting round the axle at one side; the emptying is effected by shifting a portion of the cylinder serving as a door, so that the cacao is swept out by blades, fitted inside the drum, into boxes placed below which are furnished with perforated false bottoms and can be removed immediately to the exhaust and cooling arrangements to be subsequently described. By the shifting of the front bottom, the interior of the drum is entirely exposed and the requisite frequent thorough cleaning of the drum can be carried out easily, an advantage of this roasting apparatus that cannot be too highly estimated. This roaster is adapted for working by power; but provision is made for the application of hand labour whenever the drum happens to be suddenly stopped and the furnace has then to be shifted on one side. The drawing of tests is effected, while the machine is in operation, by means of the cased axle. In consequence of the difference in the sorts of cacao and of their different applications, the drawing of tests is the only trustworthy means of ascertaining how the roasting operation proceeds. The escape of gases given off during the roasting takes place by the outlet shown in the drawings fig. 18b. The loss of heat by radiation is very slight since the apparatus is completely enclosed in brickwork. For the same reason the consumption of fuel and the danger of fire are equally small. Any kind of fuel may be used. Since the stoking as well as the removal of soot takes place at the front, space at the sides is not needed, and several of these roasters may be set up side by side. Lehmann's apparatus is made of a size to work from 30 to 400 kilos and either for the use of a movable furnace, like that shown in the figures or for fixed furnaces and for gas fires with compressed air. This latter method of heating requires for 100 kilos of beans from 3 to 4 cubic meters of gas.

It is indispensably necessary that the beans to be roasted or to be broken should always be of the same kind, for on account of the thicker or thinner nature of the husks of different kinds of cacao, the operation of roasting takes a longer or shorter time, while uniform working of the shelling machine is dependent upon the equality in the size of the beans operated upon. The husks of roasted cacao beans are hygroscopic and consequently the roasted unshelled beans contain more water after they have been kept for a time, than they do when in the raw state. The drier the beans are the more easily can they be shelled. The roasted cacao should therefore be passed on to the next operation as rapidly as possible, or, when that condition cannot be complied with, the roasted beans should be kept in closely covered metal boxes, until they can be further treated.

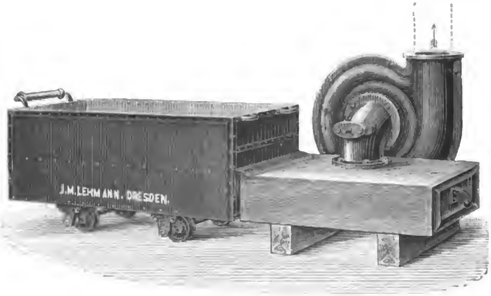
J.M.LEHMANN. DRESDEN.

fig. 19.

Some years ago a roasting machine was recommended by C. Salomon*) under the name of the "double centrifugal roaster" and it was said to excel all other kinds of roasters. Those statements have not met with confirmation in practical experience and the roasting apparatus above described is now almost always employed.

The source of heat for roasting is either coal or gaseous fuel. Dowson-gas is a very suitable fuel for the purpose, since a very high temperature is not required and the cost is less, than when illuminating gas is used. The roasting with superheated steam, that was expected to be advantageous, has not been found to answer or to be capable of effecting a sufficiently thorough roasting of the kernels throughout. One of the best known form of apparatus for roasting with steam is that constructed by the firm of Stollwerck in Cologne German patent No. 28 244 and No. 35 181.

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*) German Patent No. 49, 493 and 57210; Zeitschr. f. angewandte Chemie 1891, p. 368 and Pharm. Centralhalle 1892, p. 293 and 440.

That apparatus consists of a cylindrical sheet iron case with a roasting drum fitted inside so as to be made to revolve. The steam pipes are arranged on the side of the drum in spirals and they are so connected with the driving shaft inside the drum, that they can be moved independently of the drum.

The roasted cacao beans should be cooled as rapidly as possible before being transferred to the shelling machine, in order that the husks may be easily detached.

If the roasting drums are situated upon the ground floor of the factory, the roasted beans are allowed to cool in wide baskets, before they are taken to the shelling machine.

Provided that the roasting apparatus is situated at a sufficient height the roasted beans can be shot down into the crushing mills below.

The cooling trucks constructed by Lehmann fig. 19 are very convenient and they are well adapted for use, under most conditions, in conjunction with the exhaust arrangements as shown in fig. 19.

The trucks are fitted with perforated false bottoms and with sliding shutters at the side. After the contents of the roasting drum have been discharged into the trucks, these are wheeled over to the exhaust apparatus, shown in fig. 19 by which the cacao is so far cooled, within a few minutes, that no further alteration by heat can take place and the heated vapour is carried away by the ventilator in the direction shown by the arrow. This exhaust chamber may be made to work from both sides.

3. The crushing, shelling and cleansing of roasted beans.

Until a few years ago it had not been possible to effect the breaking of the husks and the removal of the detached portions in such a way that the husks and the radicles were perfectly separated from the particles of kernel. Nor was it possible to collect the finely divided waste particles of cacao kernel carried away by the ventilator together with the husks and so to avoid a constant considerable source of loss. But now, the requirements which a satisfactory machine is capable of meeting, have been so far advanced that not only is it possible to turn out cacao kernels or nibs nearly free from husk; but it is also possible to separate the husks almost entirely from admixture of finely divided particles of kernel. A machine that effects both those results, will not only work well but also economically. For the solution of that problem the association of German Chocolate manufacturers, therefore, offered a prize some years ago; but it is only within a comparatively recent period that the firm of J. M. Lehmann has succeeded in constructing a machine that will fully satisfy all those requirements. Another machine of a similar kind, that works very effectually, has been made by Breuer in Pirna.

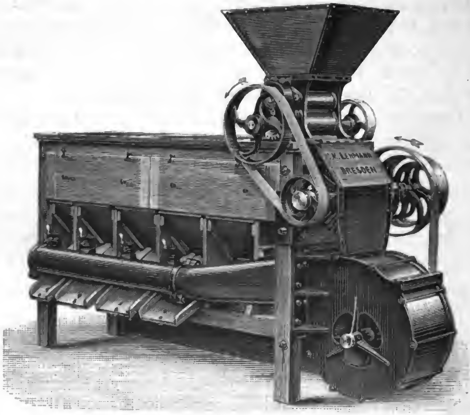

fig. 20.

In the case of all machines employed for breaking, shelling and cleansing the roasted cacao beans, the first step is to reduce the beans into small fragments. The portions of husk detached in that operation are for the greater part separated from the fragments of kernel by a current of air driven through the apparatus in a direction opposite to that in which the beans travel through the apparatus; in this way the husks are made to pass from below to a receiver situated at a higher level.

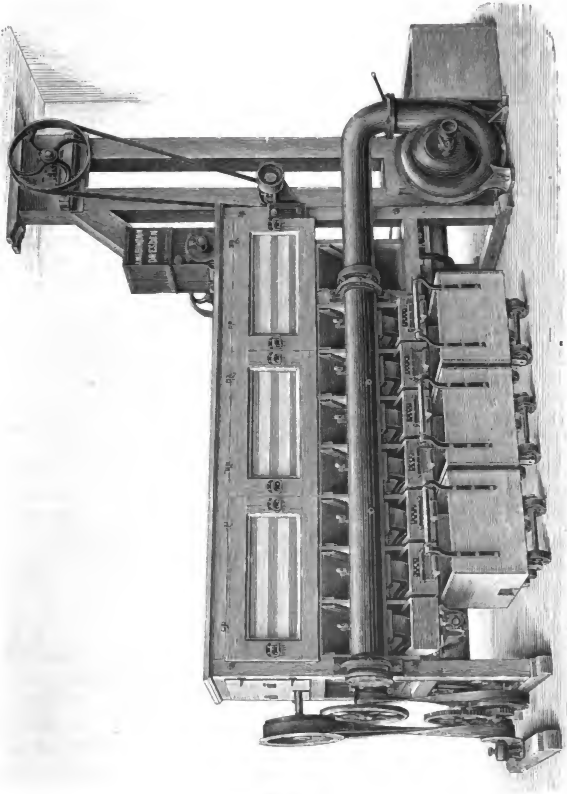

fig. 21.

In Lehmann's apparatus, represented at fig. 20 and 21, the cacao is first fed to a crushing arrangement of regulated capacity. The fragments fall into a cylindrical screen, the first compartment of which removes dust, while the subsequent compartments sort the fragments according to their size. Under each compartment there is a shaking board traversed by a current of air driven along it, that is capable of being regulated so as to effect the separation of particles of kernel from the particles of husk which are of the same size, but specifically lighter. The whole of this machine is constructed of iron, so that it is very durable. The several parts are readily accessible and the sifting screens can be easily cleaned. The cacao is well broken without yielding an impure product; consequently, by passing only once through the machine, the waste and dust are reduced to a very small amount. The husks remain in tolerably large pieces, and quite free from dust. The machine represented by fig. 20 yields the cacao nibs, in three sizes; it is capable of working from 600 to 750 kilos daily. Another machine of Lehmann's, adapted for larger works, is represented by fig. 21; it is of similar construction to that shown in fig. 20. The beans are carried to the crushers by an elevator, and they are delivered in six different degrees of subdivision, the dust being also separated from the husk. Any cacao that has not been crushed sufficiently, as well as the cacao carried away with the husk, is automatically carried back to the elevator by an arrangement that is not provided in the machine represented by fig. 20. The machine shown in fig. 21 is driven by bands with 2 horse power, No. 20 requires only, 0,3 horse power.

According to Lehmann's account practical trials of the machine fig. 20 gave the following results:

756 kg roasted Machala beans yielded 61 kg husk and 34 kilos waste. Assuming that difficultly separable waste to consist of $^1/_3$ its weight of husk and $^2/_3$ of kernel fragments 61 + 12 kg = 73 kg of husk would be separated from the 756 kg or 9,7 percent. In another trial, 2090 kg roasted Thomé beans yielded 152 kg husk and 79 kg of waste. On the assumption above stated 152 kg + 27 kg = 179 kg or 8,5 or 8,5 percent of husk was separated; that result being to some extent due to the circumstance that the husk of Thomé cacao is very thin and light.

In the preparation of chocolate and especially cacao powder (easily soluble cacao) it is important that the crushed material first yielded by the crushing machine, should be again subjected to purification in order to separate the hard radicles which would be prejudicial in those respects. The gritty sediment from decoctions of cacao powder made from shelled beans, only consists of those particles.

Lehmann effects the removal of the radicles by means of the machine represented by fig. 22. (Design registered in the German Empire. No. 24,989.) In that machine the finer siftings from the crusher are transferred to the feeding arrangement under which is fitted a small blower that removes any still remaining portions of husk. The cacao together with the radicles, falls upon a shaking sieve which allows the radicles and the cacao particles of the same size, to pass through it, while the larger particles of cacao, thus purified, travel along over the sieve and fall out, into a sack hung at the end. The radicles

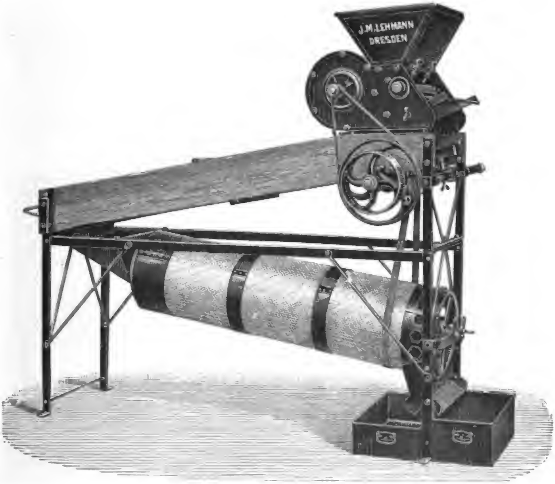

fig. 22.

and the particles of cacao then pass along a cylinder with small cavities punched on its inner surface (fig. 23) and while the cacao particles remain in those cavities during the rotation of the cylinder, the radicles of more elongated form which do not fit into the cavities, are caught up by a separator (1) and prevented from passing on. The cacao particles are made to fall into a trough (3) by a brush (2) working against the cylinder and are carried away by a worm. (4) That process

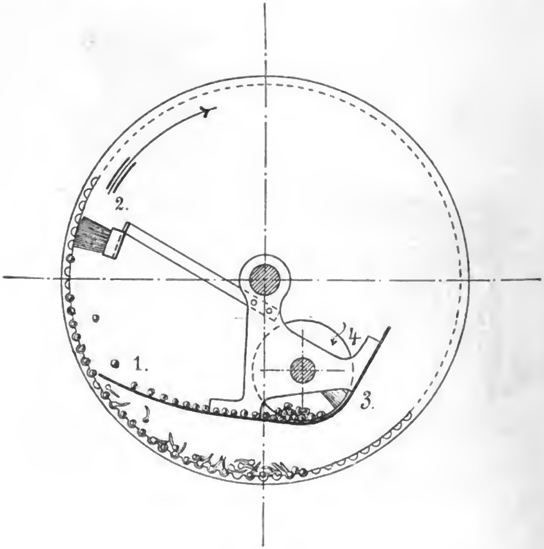

fig. 23.

goes on along the whole length of the cylinder in such a way that eventually the radicles and the cacao particles are delivered from the machine separately.

Such a machine has 3 shifting sieves and 2 iron receiving boxes. These machines are arranged for working by hand as well as by power and they require from 0,2 to 0,3 horse power; they are constructed to work from 25 to 50, 75 or

100 kg of cacao per hour. In using the crushing machine fig. 21 it is convenient to connect the radicle separator with it, by means of the elevator and worm fittings, so that the last two siftings of the crushing machine are continuously transferred to the radicle separator. The dust passing from the crushing machine contains almost equal parts by weight of cacao particles and husk particles. It is therefore capable of being used up for the so called husk masses. If the dust is not to be turned to account in that way it is advisable

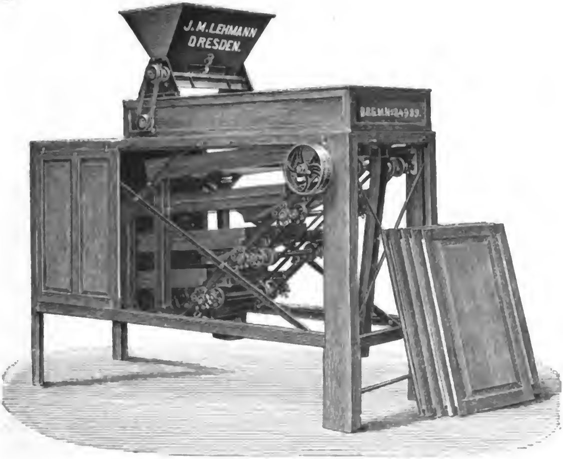

fig. 24.

to pass it through the machine constructed by Lehmann for purifying the dust fig. 24. By that means a large portion of the cacao particles may be separated by sorting and sifting, so as to be applicable for a better purpose.

This machine is capable of cleaning from 20 to 25 kilos of dust per hour with only 0,3 horse power.

The advantage and economy resulting from the use of these crushing and cleansing machines will be obvious on consideration of the data afforded by the numerous experiments carried out by Lehmann. Formerly the loss experienced in the preliminary treatment of cacao, by picking, roasting, crushing, shelling, and cleansing, amounted to as much as 30 percent, but by the use of Lehmann's machines, that loss has been reduced to the extent shown below.

The loss of 823 kg Machala beans, unroasted, was:

a) in picking	3·6 kg
b) ,, roasting	63·5 ,,
c) ,, shelling	61 ,,
d) ,, dust	34 ,,
	162·1 kg or 20 %,

without taking into account the application of the waste; 2267 kg St. Thomé raw cacao lost:

a) in picking	5 kg
b) ,, roasting	170 ,,
c) ,, shelling	152 ,,
d) ,, dust	79 ,,
	460 kg or 18 %.

According to those data the use of these machines admits of a saving of about 10 percent more material than in former work.

In connection with these particulars it is also of interest to refer to the qualitative and quantitative composition of the various waste products of the manufacture. Filsinger *) has at the instance of the association of German Chocolate manufacturers, examined with that object a mixture of 50 pounds of large Machala beans with an equal quantity of small beans, after passing it, through a shelling machine of the most modern construction, and he thus obtained:

70 pounds	large kernels,
9·2 ,,	medium kernels,
0·8 ,,	radicles,
10 ,,	husk (outer woody shell),
4 ,,	cacao waste,
6 ,,	other loss,

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*) Zeitschrift für öffentliche Chemie 1898 p. 810.

The 4 pounds of cacao waste yielded by further sifting:

a) kernel	I. sort	250	grammes,
	II. ,,	50	,,
	III. ,,	220	,,
	IV. ,,	25	,,
b) husk	I. ,,	185	,,
	II. ,,	55	,,
	III. ,,	370	,,
	IV. ,,	80	,,
c) cacao dust		725	,,
d) waste		30	,,
e) loss		10	,,
		2000	grammes.

Chemical analysis of these portions gave the following results:

	Percentages			
	Ash	Sand	Fat	Fibre*)
1. Husk 10 % of the raw cacao	11·15	1·90	4·50	21·36
2. Cacao waste 4 % of the raw cacao	4·80	0·35	15·40	16·31
3. Seed shells I. sort 0·37 % of the raw cacao . .	6·70	—	21·64	10 29
4. „ „ II. „ 0·11 % „ „ „ „ . . .	7·10	—	18·39	8·75
5. „ „ III. „ 0·74 % „ „ „ „ . . .	7 20	—	15·76	12·16
6. „ „ IV. „ 0·16 % „ „ „ „ . . .	7·80	—	16·40	12·74
7. Cacao dust 1·45 % of the raw cacao	11·75	—	22 06	8·40
8. Waste 0·06 % of the raw cacao	7·05	—	20·44	9·81

From these data it is evident that there is a great difference between the chemical composition of the so called cacao waste and that of the exterior ligneous shells. From the large amount of fat present in the former material it might be regarded, in the full sense of the term, as a cacao constituent and, for that reason, its presence in cacao preparations should not be objected to, while the husk containing as much as 22 percent of woody fibre cannot be considered a cacao constituent in the same sense.

4. Mixing different kinds of cacao beans.

Mention had already been made of the difference in the taste of the various sorts of cacao. The better the beans have been fermented the milder and more aromatic is the taste, while imperfectly fermented beans have an astringent and sometimes acrid taste. The manufacturer therefore endeavours to improve the taste of an inferior kind of cacao, by mixing it with better sorts, so as to produce a finished article that will meet with approval.

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*) The determination of the fibre has been executed according to the Weender-process.

Nevertheless it is a general rule that for the preparation of the finest qualities of chocolate, only the better sorts of beans should be employed, such as those of Caracas, Ariba, Puerto Cabello, while in the manufacture of lower qualities mixtures of various sorts of cacao may be used in proportions regulated according to their price in the market.

In many instances the proportions of such mixtures are kept secret by manufacturers under the impression that they are important, and each maker has his own speciality in that respect. The following are examples of working formulæ:

1.

$\left.\begin{array}{l}\text{Caracas}\\ \text{Guayaquil}\end{array}\right\}$ of each 1 part.

2.

Caracas = 1 part
Bahia = 5 parts.

3.

$\left.\begin{array}{l}\text{Maracaibo}\\ \text{Maragnon}\end{array}\right\}$ of each 1 part.

4.

$\left.\begin{array}{l}\text{Trinidad}\\ \text{Maragnon}\end{array}\right\}$ equal parts.

5.

Caracas = 1 part
Maragnon = 5 parts.

6.

Ariba = 1 part
Surinam = 1 part
Trinidad = 1 part.

7.

Ariba = 1 part
Trinidad = 1 part
Surinam = 1 part
Caracas = 1 part.

8.

Ariba = $^1/_2$ part
Trinidad = $^1/_6$ part
Surinam = $^1/_6$ part
Caracas = $^1/_6$ part.

9.

$\left.\begin{array}{l}\text{Machala}\\ \text{St. Thomé}\end{array}\right\}$ equal parts.

Ceylon cacao is but seldom employed for mixing and is almost exclusively applied in making coatings in order to produce them as pale coloured as possible.

The beans are weighed out in suitable proportions for the preparation of the cacao mass.

5. Trituration of the cacao mass.

Formerly the roasted, crushed and decorticated beans were frequently ground before being transferred to the incorporating machine ("Melangeur", that will be described later) in which they were then reduced to a finer state of subdivision and finally mixed with sugar. For the operation of grinding, mills of various construction were employed (those of Weldon, Pintus etc.). But in the course of time the mills used for the preliminary grinding were replaced by the melangeur by means of which the cacao mass was reduced to the very fine state of division that is requisite in order to effect complete intermixture with the sugar to a perfectly homogenous mass (chocolate) that ultimate result was however effected only by the cylinder rolling machines. (French method.) At the present time, the kernels are ground so fine as to become

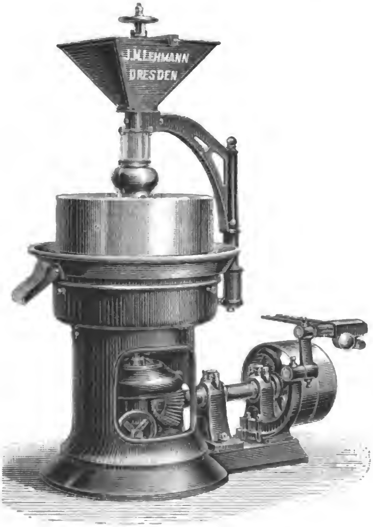

fig. 25.

semiliquid, and that is done whatever the purpose to which cacao is to be applied. That object is effected by means of mills of the modern kind, two of which, constructed in Lehmann's factory, are represented by figs. 25 and 26, while the construction of a duplicate action machine in shown by fig. 27.

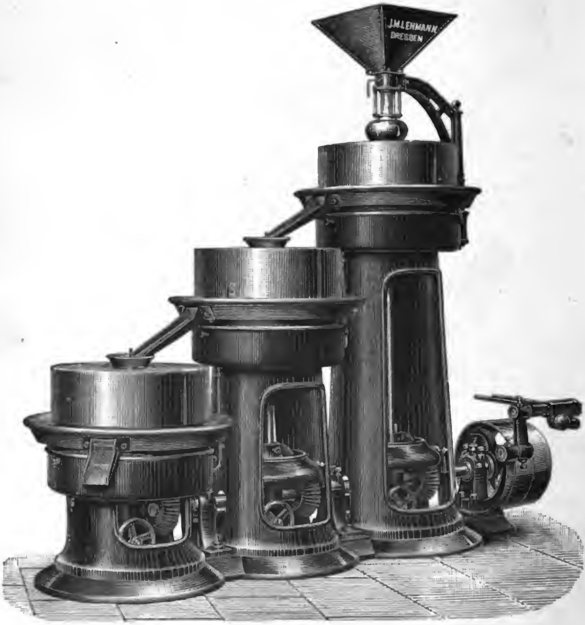

fig. 26.

The cacao mills which were formerly but seldom met with in chocolate factories are now the most indispensable necessaries since they have the advantage:

1. of rendering the cacao mass more easily miscible with the sugar on account of the liquid state to which it is reduced.

2. of effecting the mixture with sugar more rapidly.

In the manufacture of fine chocolate the frequent passing of the material through the rollers is intended not so much to effect finer subdivision as to ensure the utmost intermixture of the component parts. The more time that can be devoted to the thorough mixing of the sugar and cacao mass the better is the chocolate produced. The appreciation these mills have met with has also led to continually increased requirements as to the quality of chocolate, so that the use of simple machines, like that shown in fig. 25, has been succeeded by a twin mill fig. 27 and within the last eight years by a triple machine fig. 26. This latter mill satisfies probably all the requirements that can be demanded of such a machine, and it has in consequence met with general approval both at home and abroad. It turns out cacao in a state of ex-

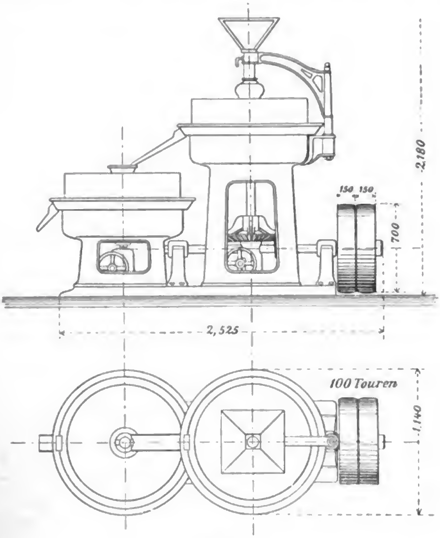

fig. 27.

tremely fine subdivision; it does not affect the aroma or flavour of the best kinds of cacao, and it does not require more than from one to one and a half horse power to work it, or much attendance. A triple working mill will turn out from 300 to 400 kilos of finely ground cacao daily or larger quantities if the utmost degree of trituration is not requisite. The working capacity of the mill is greater in proportion as the amount of fat in the cacao is greater, provided that the roasting has been thorough. That is a matter of special importance in connection with the working capacity of the mill. Lehmann's triplicate mill represented by fig. 26 is of the kind termed "over running"; it acts only by its own weight and consequently has not that detrimental action upon the cacao that was experienced in the use of the "under running" mills that were tried some years ago. This triplicate mill has only three equal sized stones of moderate dimensions because the use of larger stones is attended with greater evolution of heat. About the middle of the last decennium an attempt was made to introduce mills fitted with smaller stones above and larger ones below and afterwards a reverse arrangement was tried. Those alterations do not appear to have been attended with advantageous results in practice; the triplicate mill still being the most approved form. The working of this mill is so conducted that the crushed cacao is fed from the hopper to the upper pair of stones which have a disintegrating arrangement fitted in their centre. The cacao prepared by that means passes between the surfaces of the stones and escapes in a semiliquid condition. It is then carried by a channel to the second mill stones, for further grinding and is finished in the third pair, leaving the mill in a semiliquid condition. The perfect levigation of cacao, without detrimental heating of the mass, is possible only in that way. If it be only desirable to increase the working capacity, the Lehmann's double mill may be used with advantage, as it is capable of turning out from 700—800 kilos daily. The accompanying fig. 27 shows a mill of that kind fitted with very much larger stones. In other respects the operation of grinding in this mill is carried out as above described. Cacao mills with one stone are applicable for grinding cacao kernels to make chocolate mass, while the double and triplicate mills are more suitable for the production of cacao powder.

6. Mixing the ground cacao mass with sugar and spices to produce chocolate.

The intimate mixture of the cacao with sugar can be effected only when the material is heated to a temperature rather above the melting point of cacao butter, or from 35° to 40° C., consequently the incorporating machine (Melangeur) in which that operation is carried out, is provided with a steam jacket. In mixing chocolate, it is advantageous to have the cacao in a semiliquid condition, and for that reason the ground cacao coming from the mills is received in vessels heated by steam (fig. 28) and fitted with suitable taps for drawing off the mass as it is required. Formerly the liquefaction was effected in the melangeur, the cacao mass being fed into it in lumps. But in applying heat to the melangeur there was some risk cracking the bottom plate and, at the same time, the mixing was retarded. Now it is usual not only to warm the cacao mass beforehand, but also to warm the sugar, by keeping it in hot closets so that the material operated upon in the melangeur has a uniform temperature and loss of time is avoided.

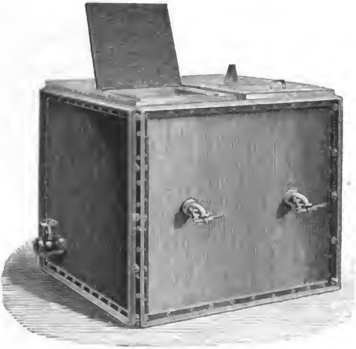
fig. 28.

In some large factories the actual incorporation of the cacao and sugar in the melangeur is preceded by a preliminary mixing operation with larger quantities than can be dealt with at once in the melangeur. By that means the work is made easier while the machine rooms are kept free from dust. For that purpose Lehmann's preliminary mixer is advantageously applicable. It is shown by fig. 29 fitted with a shifting trough. Such a machine is capable of mixing from 300 to 400 kilos of material within 30 minutes, when the cover is closed down. The mixing is effected by means of two suitably shaped blades.

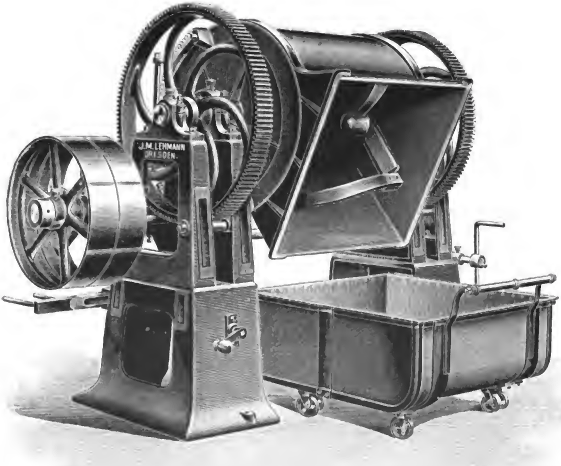

Fig. 29.

The warming of this machine is effected by a steam jacket. When the operation is complete the mixed material is turned out into portable troughs that can be kept warm in a hot closet until the contents are transferred to the melangeur for further treatment.

It has become customary to keep the chocolate mass thus prepared for several days*) at a temperature of 20° to 40° C. to allow the sugar to thoroughly penetrate the entire mass before it is further worked. After that time it is finished in the melangeur and in the roller mill and mixed with spices, vanillin ethereal oils etc.

a) Trituration of chocolate mass.

In describing the mixing machines it will be unnecessary to dwell at length upon those machines which were formerly used for trituration, but merely to state briefly the priniciples of their construction.

The triturating effect was produced:

1. by rollers running backwards and forwards**) upon a bed.
2. by several cones rotating in a circle upon a disc-shaped bed.
3. by means of rotating stones running in a trough.
4. by means of several cylindrical rollers.
5. by means of a grooved cone and a grooved casing.

At the present time only such machines as those referred to under 1 and 4 are still in use, those referred to by 3 are less frequently used and they will be described in detail subsequently.

The machines of the kind 1 and 3 are used before the cylinder rolling mills 4. The former are not capable of effecting a sufficiently intimate incorporation of the cacao mass with sugar or the levigation of chocolate that is requisite; so that final operation is now carried out by means of the cylinder rolling mills.

The machines constructed in the manner described under 3 were introduced by G. Hermann of Paris, but they are no longer made at the present time. Since they have some historic interest and are typical of the development of the melangeur a representation of such a machine is given in fig. 30.

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*) For that purpose boxes with handles and having a capacity of from $16^1/_2$ to 44 litres are employed, as well as the portable troughs previously mentioned and also boxes stamped out of sheet steel, either tinned inside or not, such as are made by the works at Brackwede near Bielefeld; A. Reiche's Comp. in Dresden-Plauen also make boxes for the transporte of chocolate mass in factories.

**) Muspratt Encyclop. Handbuch der techn. Chemie Vol. IV, p. 1902.

The ellipsoid runners a made of granite work in the trough i which is also of granite and is fitted with the casing h. The runners rotate on their axes b so as to move in a circle. The two arms of the axis b have at the centre an elliptical ring with a quadrangular opening, into which fits the similar shaped part of the vertical shaft c fitted with the toothed wheels, d and d, which are set in motion by power transmitted to the shaft and its connections. The arm b has some play downwards, so that it can adjust itself vertically according to the greater or less quantity of material in the mill. The two steel blades, e and e', are shaped to fit the cavity of the trough; being connected with the shaft c they revolve with it and sweep down the cacao mass adhering to the sides of the mill. Between the foundation k and the trough i there is a space l into which steam can be introduced through f, the condensed water passing away by g.

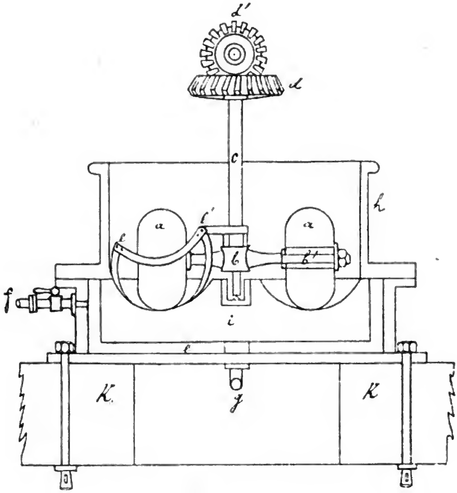

fig. 30.

All machines of this kind have now been displaced by the melangeur which is capable of turning out a much larger quantity of material with a relatively smaller expenditure of power. The operation of mixing chocolate is not merely one of mixing, for the pressure exerted by the runners is also an indispensable factor. It is on that account the ordinary mixing machines have not proved serviceable whatever may be their construction, especially in the case of chocolate containing a small amount of fat, as is the case in the cheaper kinds, while the addition of cacao butter to facilitate the working of the machine would considerable increase the cost of production. Melangeurs are generally constructed on the same principle as the edge runner grinding mills which are so much used for various purposes; but they differ from them in so far as the bed stone revolves, while the runners merely rotate on their axes without revolving.

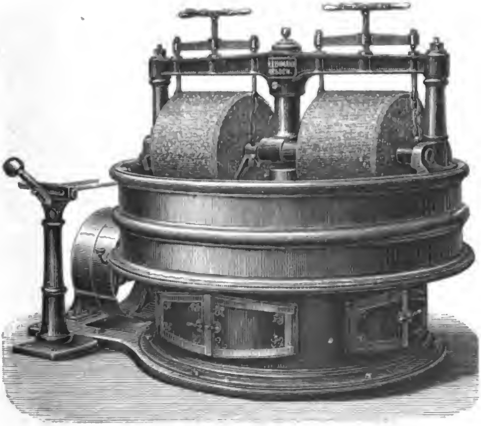

fig. 31.

The melangeur with travelling bed stone, as constructed by Lehmann, is shown at fig. 31; it is fitted with an arrangement for lifting out the runners.

The space occupied by such a machine is about 2 cbm and, in working, it requires from 0,8 to 1,5 horse power.

The bed stone as well as the runners are made of granite. Each runner has an axis working in plummer blocks, so that

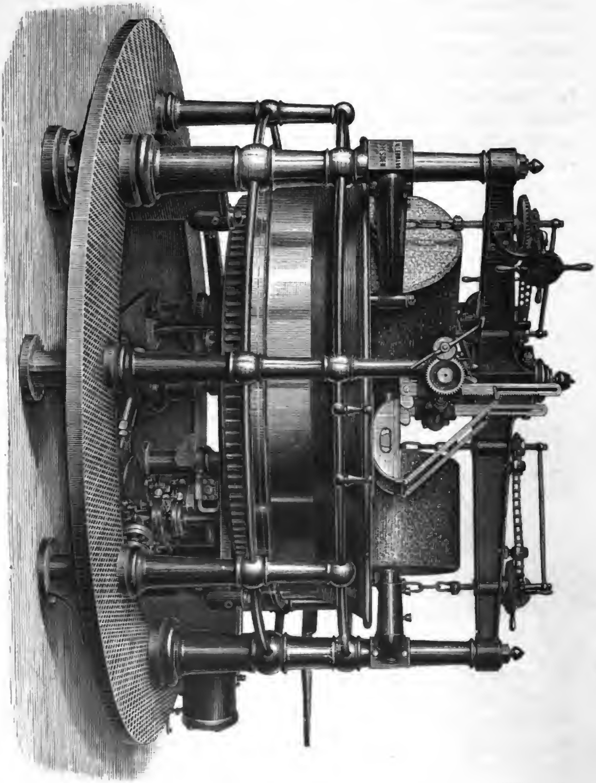

fig. 32.

it can be lifted out independently of the other one. By that construction the runners are prevented from taking an oblique position as was the case with the mills formerly made, since one runner would be forced downwards or tilted on its outer edge whenever the other one was raised up somewhat. The bed stone of this machine revolves and it is easily heated by steam pipes from below. One important advantage of this machine is that being low it can be very easily charged and emptied. The contrivance for lifting out the runners prevents the thumping upon the bed stone that might otherwise readily happen when starting the machine, it also lessens the wear of the driving bands; moreover, large lumps of sugar or cacao are very readily crushed down and, thus, the working is much facilitated. The emptying of the melangeur is readily and safely effected, while the bed stone is revolving, by holding a shovel so that the cacao is thrown up against the shovel. A melangeur of this construction is represented by fig. 32; it has three runners and underneath the bed stone is fitted a steam engine which supplies driving power, the exhaust steam being used for heating the machine.

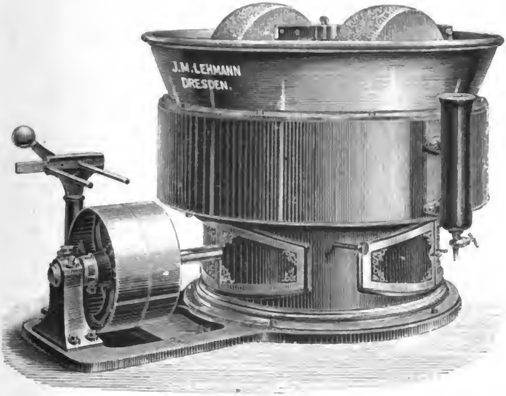

fig. 33.

Another form of melangeur, with fixed dish shaped bed stone and round edged shifting runners, has been used for many years in the manufacture of cacao preparations: see fig. 33.

each of the runners has a separate axis and they work independently of each other. The heating is effected by hot water and steam pipes, so arranged as to prevent cracking of the bed stone . To prevent loss of heat by radiation the machine is fitted with a jacket. The space required amounts to about 2 or 2,5 cbm and, for working, the machine requires from 0,8 to 1,0 horse power.

The melangeur with revolving bed stone is equally adapted for mixing chocolate mass or for grinding cacao powder. The construction with fixed bed stone and revolving runners fig. 33, according to the principle of the ordinary edge runner mill, is more especially suited for the preparation of cacao powder and for working cacao that has been partly deprived of its fat. When it is used for making cacao powder, it can be fitted with a hood to prevent dust.

b) Levigation of the chocolate mass.

The highest degree of subdivision and homogeneity of chocolate mixtures is attained by the use of cylinder rolling mills. Every kind of chocolate must be passed through the rolling machine at least once or twice, even when finely powdered sugar is used in the manufacture. In this latter case the effect of the rolling mill is rather that of thorough intermixture than that of powdering finely. The best qualities of chocolate are passed through the machine six or eight times and even more. In the last of those operations the material is often fed into the machine in the state of blocks and rubbed down. The rollers are made of granite because of its hardness and the other characters which make it suitable for the purpose. But every kind of granite is not equally suited for rollers.

Apart from the fact that granite rarely occurs in compact masses free from flaws, neither porphyry nor the stone known as granite is adopted for making mill rollers. The kind that is used has a hardness between that of porphyry and ordinary granite; it is known by the name of diorite and possesses considerable hardness, besides being specially suitable for grinding.

This diorite — quarries of which belong to the chief makers of rolling machines such as the firm of Lehmann — is far superior, as regards the above mentioned characters, to porcelain or any as other artificially produced material.

The priniciple of the roller machines is that the soft chocolate requires that the cylinder surfaces, moving in opposite directions, shall have dissimilar velocities. This principle of the differential velocities of the cylinders is of the utmost importance in connection with the levigation of chocolate. Two or more rollers are therefore made to work against each other; but they are fitted with driving wheels having an unequal number of teeth. By that means the rollers fitted with wheels having the smaller number of teeth revolve more slowly than those fitted with wheels having a larger number of teeth.

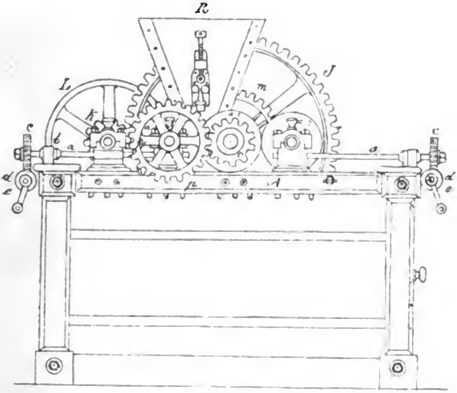

fig. 34a.

The construction of the machines now in use differs from that of the older machines more or less, and a typical machine of this kind is represented by figs. 34a and b *) in elevation and plan.

The granite rollers a^1 a^2 a^3 are each fitted with an octagonal axis of iron that is somewhat thicker at the interior part and they are mounted upon a frame as shown in the drawing. The sockets of the central roller a² are fixed and each one is held in position by three set screws; those of the two other rollers can be shifted along grooves in the frame work, and when the cylinders a¹ and a³ have been brought into proper position relatively to the cylinder a² they are held fast by the set screws p.

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*) This description is taken from Muspratt's Encyclop. Handb. d. Techn. Chemie Vol. IV p. 1808 and Mitscherlich: Der Kakao u. die Schokolade p. 115.

For the purpose of this adjustment, there is at each end of the machine a horizontal wrought iron shaft f that can be turned by the winch e, and these shafts are fitted with two endless screws d working in the corresponding wheels c fitted upon the spindles a, which screw in and out of the bearing blocks of the rollers a¹ and a², but turn only in the fixed collars b without being shifted from their place. The result is that on turning the cranks e the corresponding cylinder a¹ or a³ is moved nearer to, or further from, the central cylinder a², while the position of all of them always remains parallel. The shaft Q is set in motion by the driving wheel L fitted with the loose wheel L¹. It acts first upon the cog wheel K which works in the larger wheel J on the axle of the central roller a². That works in the cog wheel O and the wheel P fitted to the roller a¹ driving them as well as

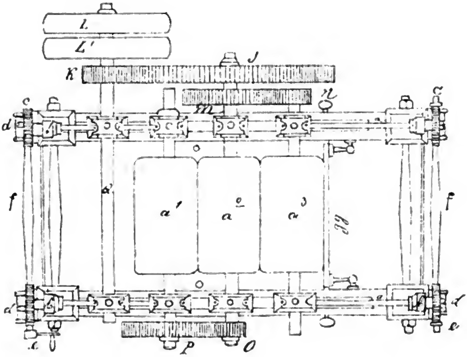

fig. 34 b.

the wheel M and the pinion N of the roller a^3. The result is that the axle a^2 makes $1\frac{3}{4}$ revolutions and a^3 $6\frac{1}{8}$ revolutions while a^1 in the same time makes only one revolution.*)

The cacao or chocolate is supplied to this machine by the hopper R which is placed between the rollers a^1 and a^2. The pasty mass adhering to the rollers is carried forward by the quicker moving roller a^2 and it is ground finer between the rollers a^2 and a^3, after which the material is removed from a^3 at the outer side by an adjustable blade gg and then falls down into a receptable below.

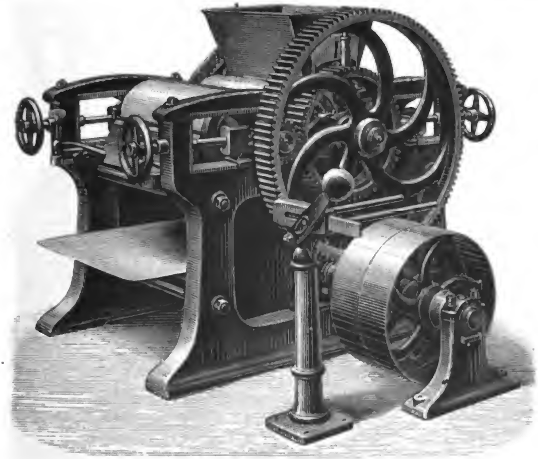

fig. 35.

In the course of time roller machines have undergone various alterations. The accompanying drawing fig. 35 represents the most recent construction. The axle blocks are fitted above to secure greater stability. The roller next to the blade has a reciprocating motion. The frame work is made smooth without ornament, so that the machine can be easily kept clean.

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*) That is, in case the wheel M has 42 teeth, N 12, O 20, and P 35.

The most remarkable innovation in this part of the chocolate manufacture is the battery roller machine. Evidently the more rollers there are in a roller machine, the greater their length and diameter, the greater also will be the efficacy of the machine. For that reason, combinations of two machines each with three rollers have been adopted or machines have been constructed in which two, three, or more roller systems have been arranged one over the other.

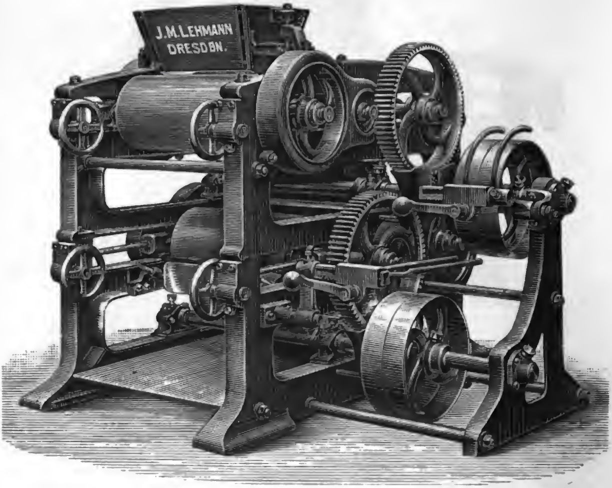

fig. 36.

The chocolate mass is generally supplied to the machine at the roller a^1 in the lower system and the roller a^2 carries it forward to the roller a^3 of the second system. (See fig. 34b page 132.)

Quite recently, battery roller machines have been superseded by machines, first constructed by Lehmann, with six or nine rollers and they are gradually being more used than battery roller mills which have the disadvantage of taking up much space, while they are difficult to work and to regulate.

The modern six and nine roller machines shown in figs. 36 and 37 are strictly speaking arrangements of triplicate rollers placed one above the other. Consequently they occupy only the same space as one triplicate machine and they can be worked as easily as the latter.

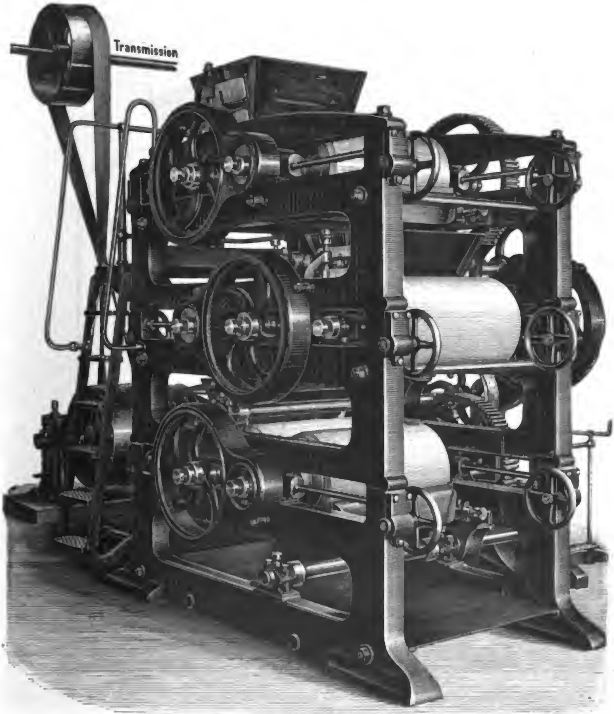

fig. 37.

The accompanying illustration fig. 37a shows a nine roller machine in which the chocolate falls from one set of rollers to the other. A mass that requires to pass through the rollers three times would be worked off in such a machine in one third of the time required if a triplicate roller machine were used, with corresponding economy in other respects. The nine roller machines are provided with an elevated stage and steps and, for feeding purposes, they are adapted to the working of a factory as occasion may require.

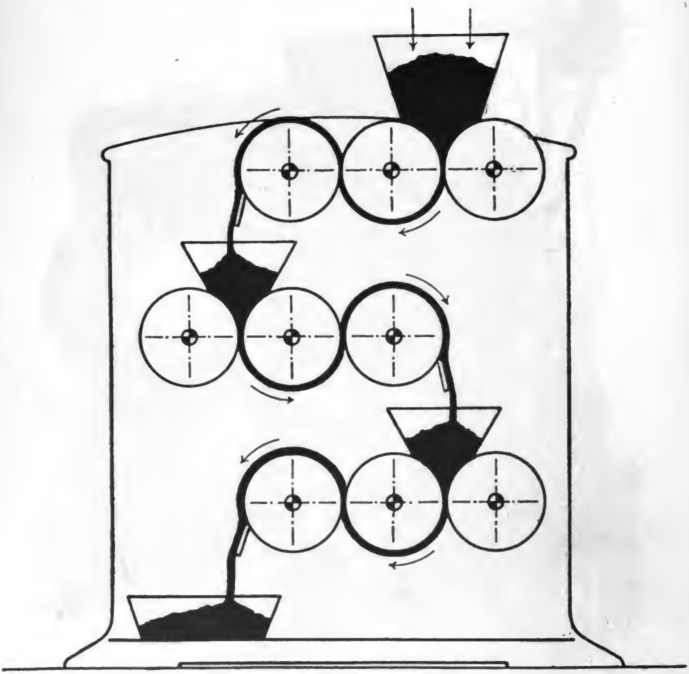

fig. 37 a.

The addition of spices or ethereal oils and of the substitutes for those additions, such as vanillin, is not made until the process of levigation in the roller machine has been nearly completed, the object being to prevent the loss of aroma that would be caused by long continued treatment of the material in the melangeur and the roller machine.

c) Proportions for mixing cacao mass, sugar and spices.

The relative proportions of cacao, sugar, and spices, as well as of starch as in the manufacture of the cheaper sorts, are very different. Generally speaking 50 or 60 parts of sugar are added for 50 or 40 parts of cacao mass; the following are a few formulæ applicable for the production of those kinds of pure chocolate that are most used.

A. Hygienic chocolate.

Cacao mass
Powdered sugar } equal parts of each.

B. Spiced chocolate.

a.

Cacao mass	4	kg
Sugar	6	„
Cinnamon	72	gr
Cloves	38	„
Cardamoms	16	„

b.

Cacao mass	4	kg
Sugar	6	„
Cinnamon	130	gr
Coriander	8	„
Cloves	88	„
Oil of lemon	2	„
Cardamoms	16	„

c.

Cacao mass	5	kg
Sugar	5	„
Cloves	80	gr
Cinnamon	220	„
Mace	8	„

d.

Cacao mass	5	kg
Sugar	5	„
Cinnamon	100	gr
Vanilla	100	„
Or Vanillin	2·5	„
Mace	2	„
Cardamoms	4	„

e. *Spanish spiced chocolate.*

Cacao mass	5	kg	Cardamoms	82	gr
Sugar	5	„	Mace	44	„
Cinnamon	116	gr	Vanilla	40	„
Cloves	50	„	Or Vanillin	1	„
			Oil of lemon	1	„

C. Vanilla chocolate.

a.

Cacao mass	5	kg
Sugar	5	„
Cinnamon	160	gr
Vanilla	50	„
Or Vanillin	1·2	„

b.

Cacao mass	4·5	kg
Sugar	5·5	„
Cinnamon	150	gr
Vanillin	1·5	„

c.

Cacao mass	4	kg
Sugar	6	„
Cinnamon	120	gr
Cloves	20	„
Vanillin	1·6	„

The powdered spices may be proportionately replaced by the corresponding essential oils, attention being given to the remarks on that point at page 93.

When the chocolate, consisting of equal parts of cacao mass and sugar, contains too much fat for convenient working, in consequence of the high percentage of fat in the beans used, that defect may be remedied, in the case of the better qualities, by a sufficient addition of a similar mixture made with beans from which fat has been removed; in the case of the cheaper kinds of chocolate the same result may be attained by a sufficient increase in the proportion of sugar, for instance 55 to 60 parts for 45 or 40 parts of cacao mass (see the formulas for spiced chocolate a and b, or those for vanilla chocolate b and c). The cheaper kinds are generally prepared with a much smaller proportion of cacao mass and consequently they contain a larger amount of sugar. If the sugar exceeds 60 percent the chocolate cannot be moulded and in that case some cacao butter must be added in order to produce a mass that can be moulded. Chocolate of that kind would have a composition approaching the following proportions:

Cacao mass	25	parts
Sugar	67	„
Cacao butter	7	„
Spices and Vanillin as above	1	„

In the preparation of chocolate masses for experimental purposes the quantity operated upon should not be very large; one or two kilos is quite sufficient for such operations. Lehmann's firm makes a small melangeur as well as a roller machine, both of which can be worked by hand or by power.

7. Preparation of chocolate creams.

The sweetmeats, known under this name, or "chocolats fondants" have lately become very popular. They are made of soft chocolate and, so far as can be ascertained, were first produced in Switzerland. The material used is readily fusible, owing to the large amount of fat it contains, and in that respect it differs from ordinary chocolate. When first introduced, the opinion prevailed that the greater degree of fusibility could only be produced by considerably increasing the amount of fat. But a very large amount of fat is objectionable, not only as affecting the taste of chocolate, but also because the fat is indigestible. The use of a large proportion of fat has therefore been abandoned, and the required character, of readily melting, has been obtained by subjecting the chocolate to mechanical treatment. The machines used for that purpose are termed "conches", because the trough, in which the chocolate is rubbed under a cylinder, has somewhat the shape of a long shell. For the preparation of chocolate that is to be worked in that way the necessary conditions are:

1. That the chocolate should have been ground very fine.

2. It must contain such an amount of fat as to run when warmed. That is to say, it must not be as thin as coating material, but nevertheless softer than the ordinary cake-chocolate of good quality.

The temperature of the machine used should not be higher than 50°—60° C.; heat can be applied by means of steam, or otherwise, according to the arrangement of the machine. In manufactories with waterpower, or electricity, the machine may be worked continuously day and night, but when worked only during the day it must be kept warm overnight.

Figures 38 and 39 represent quadruple machines, as constructed by Lehmann: in fig. 38 four troughs (conches) are arranged in pairs, end to end, while in fig. 39 they are placed side by side. The bottoms of the troughs, as well as the rollers working

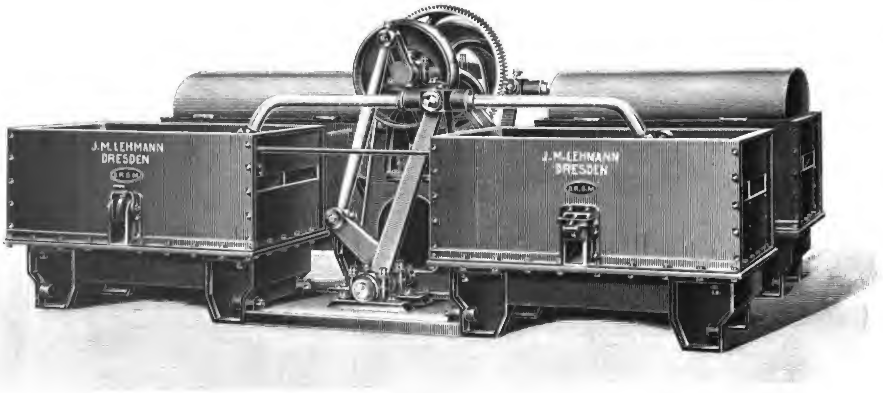

fig. 38.

in them are made of granite. The sides are made concave in the machines of latest construction, so that the soft mass tends to fall over to the centre, while being rubbed, instead of being

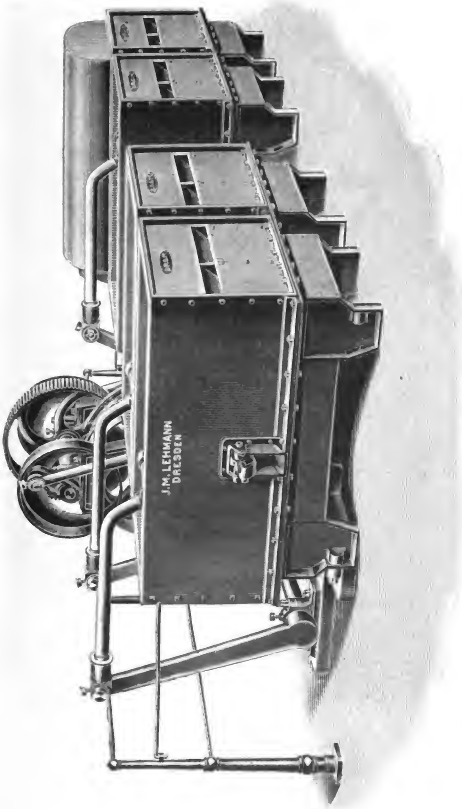

fig. 39.

pressed upwards as was the case when the sides of the troughs were perpendicular. By this improved construction of Lehmann's machines very much larger quantities can be worked (from 170 to 200 kilos in the place of from 60 to 75 kilos), so that in 40 hours a quadruple machine will turn out 800 kilos of finished material, or 200 kilos daily. The mixing troughs of these machines are covered with hoods. This machine can be warmed most conveniently by ribbed steam radiators fixed underneath. It does not require continuous attention while working. After being worked from 40 to 48 hours the chocolate becomes readily fusible and it acquires the smooth consistence, as well as the agreeable taste that is desirable and characteristic of the best qualities of chocolate. Other kinds of chocolate, such as milk chocolate, can be worked in these machines, but it is more advantageous to use the ordinary melangeur for that purpose, since the fine taste communicated by the "conches" is concealed by the preponderating taste of the milk.

Chocolate creams are, from the gastronomic point of view, the finest pure chocolate preparations that are made, and there is reason for believing that this branch of chocolate manufacture will soon be very much extended.

8. Hot closets.

The manufacture of chocolate has been very considerably facilitated by the introduction of hot closets, which are now an indispensable feature of every modern chocolate factory. The chocolate that is to be rolled, as well as that which has undergone that operation, is therefore kept in boxes in these hot closets until it can be further worked up. Under that condition, there is also the further advantage that masses, which are dry and appear as if they might require more fat, improve in texture so much, after being left for 24 hours in the hot closets, that no further addition of fat is necessary. In every factory, there should be at least so much space available in the hot closets, that the whole of one days production can be stored in them; but even twice or three times as much space would not be too much to have at command. In small factories closets heated by steam, such as that shown by figure 40, are most convenient. They should be fitted with double doors, walled in and have such a capacity as to hold from 250 to 300 kilos of chocolate mass for each metre of length. Larger factories would appropriately provide a hot chamber of larger

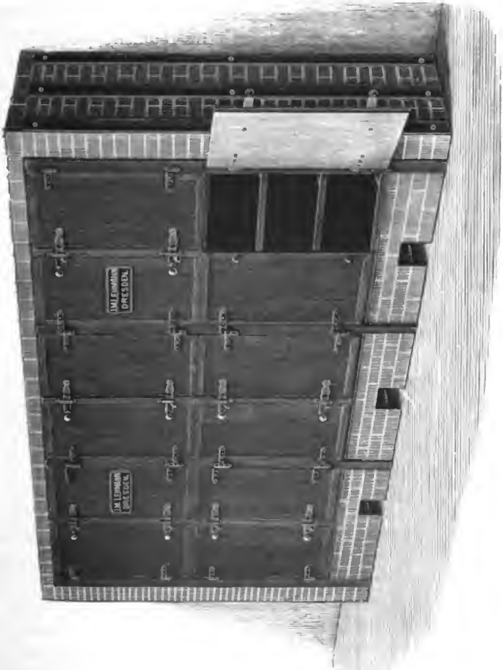

fig. 40.

dimensions, with iron shelves on the walls, that could be heated by steam pipes arranged underneath. A chamber of that kind measuring 2·8 metres in breadth (including passage) and 5 metres long would hold about 2500 kilos of chocolate.

9. Removal of air and division of the chocolate.

The chocolate, that has been through the rolling process, is kept in the hot closet until it can be moulded; but before that can be done the air introduced in working the paste, must be extracted and the mass cut up into small portions. For those purposes the mass has first to be kneaded in a melangeur, with a dish shaped bottom, until it has the requisite plasticity. A small machine of the kind used is represented by figure 41; it has only one runner for convenience in working. Between the bottom and the iron jacket is water, which can be heated by steam pipes so as to warm the stone uniformly without danger of cracking it. After being worked up, the mass is taken out in large lumps and, in order to bring it to the proper temperature for extracting the air (about 26° or 32° C. according to the season) it is spread out upon tables of hard wood, marble or iron to cool sufficiently. When the lumps have attained the proper temperature, they are transferred to the machine for extracting air. That operation is necessary because the chocolate, that is detached from the rollers in thin layers by the blades of the scraper, entangles air in the mass to a considerable extent. The machine, by which this air is removed, is shown by figure 42 in elevation. It admits of being warmed by a charcoal fire placed in the space i, or by any other suitable means. The chocolate

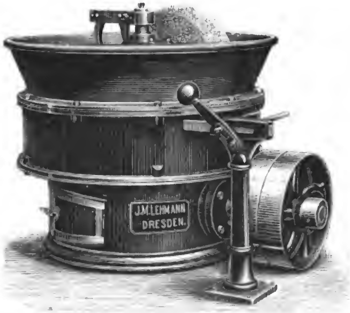

fig. 41.

mass is fed into the hopper a, at the bottom of which is an archimedian screw b, driven by the toothed wheels c d, and the fast and loose pulley e, in the direction of the arrow, so as to force the chocolate mass into the box f, through the aperture of which it escapes afterwards in a cylindrical form, almost entirely free from air, and is then received upon the travelling band h. As the mass is forced out, it is cut off either by a knife fixed to the box f, or by a double knife with adjustable blades, so as to divide the mass into pieces of the weight required for moulding. That operation requires some skill; but when that is once acquired the subdivision can be easily and accurately carried out.

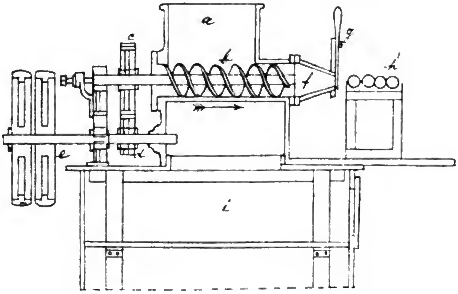

fig. 42.

The more modern machines for extracting air, though constructed in general upon the same principle, have various improvements. Thus for instance, Lehmann's machine, represented by figure 43, is fitted with an automatic feeding arrangement which is advantageous in working hard masses and it does away with the danger attending the feeding by hand. The warming of this machine is effected either with gas or steam, the arrangements for that purpose being fitted underneath the cylinder. A further improvement introduced by Lehmann is a mechanical dividing apparatus shown in figure 44, by means of which the work in a large factory is very materially simplified. The pieces of chocolate, of required weight, fall out of holes in the revolving wheel by which they are cut off and then drop upon the table beneath. This machine does its work with real precision, turning out in one day 15 000 pieces, weighing 125 grammes each. The size of the pieces delivered

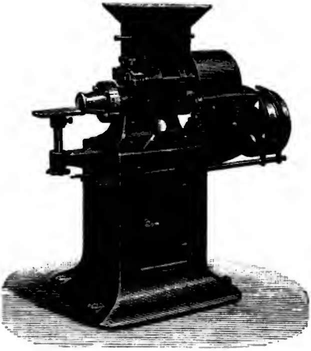

fig. 43.

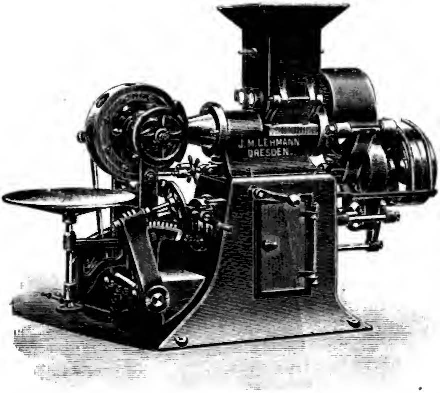

fig. 44.

by Google

by the machine may be varied by altering the size of the cavities in the wheel so as to cut off pieces weighing from 30 to 250 grammes.

10. Moulding chocolate.

The pieces of chocolate cut off to the required weight as above described, are placed separately in iron moulds which must have the same temperature as the chocolate mass. That is important in order to prevent the formation of spots upon the surface of the cakes, and in order that the fracture surface of the chocolate may not become grey. The temperature requisite for moulding small cakes is about 27° to 32° C.; with larger pieces, the temperature may be kept much below that. In summer, the moulding may be done at a lower temperature than in winter. According to a note in the Gordian (1895 No. 4), the moulding may be carried out in summer, when the atmosphere temperature is:

from 25·0° to 31·0° C.	at 26·0° to 27·5° C.
,, 18·5° ,, 25·0° ,,	,, 28·5° ,, 30·0° ,,
,, 12·5° ,, 18·5° ,,	,, 31·0° ,, 32·5° ,,

In cold weather, the moulding may be done at from 32,5° to 35° C. according to the thickness that the cakes are to be. The temperature to be maintained should be controlled by the use of a thermometer.

There are two principal forms in which chocolate is sold, that in which it is used for domestic purposes, and that in which it is consumed as an article of luxury. The kinds known as cake, rock and roll chocolate belong to the first class, the several pieces weighing 50, 100, 200, 250, 500 up to 5000 grammes. In the moulding, tin-plate is the only material of which moulds are made; these generally have a capacity rather greater than is necessary for holding the particular quantities to be moulded. The pieces of definite weight deposited in the moulds are spread out by hand and the moulds are then placed upon the shaking table, where the soft mass is soon made to sink into all the depressions of the mould. The removal of the cooled cakes is effected very easily by pressing the mould diagonally. Knocking the moulds at the back is quite unnecessary, and it only destroys the moulds.

The moulds are generally made with from four to ten ridges, so that the chocolate can be easily broken into pieces of convenient size as required for use. Any kind of inscription such as the name of a firm, may be reproduced on the cakes of chocolate by stamping it upon the moulds.

Flake chocolate is a specially prepared chocolate, that is sold loose and without being packed as the cakes are.

In those kinds of chocolate which are known as articles of luxury a distinction is to be made between;

1. Those moulds, which are in one piece and are completely filled with chocolate, so that the superfluous mass can be removed by a knife. In such cases the weight of the cakes is exactly regulated by the capacity of the moulds.

2. Those intended for moulding various figures of fruit etc., in which two or three parts make a closed space that is of the form desired.

Among the moulds of the first class are those for making small tablets or sticks, and the sweetmeats known as Napolitains and Croquettes.

The moulds of the second class comprise those for making chocolate cigars and chocolate eggs.

The moulds for small tablets, sticks etc. are made of tinplate and the several parts are enclosed in a stout iron frame, the upper side of which is ground down smooth, so that any superfluous portion of the filling can be easily scraped away. In that way from six to thirty pieces can be cast in one mould at the same time: the cooled chocolate falls out of the mould, when one corner is gently tapped against a table. In the moulds for Napolitaines projecting hooks are attached to avoid injury to the moulds.

Chocolate cigars.

These are made either by placing the chocolate mass between the two halves of the mould, which fit together exactly, or by pouring the melted mass into a hollow mould. On the large scale moulding presses are used for this purpose*). For each size and shape special moulds are required and corresponding plates in the press.

Other figures, such as fish etc., may also be produced in chocolate, by means of the moulding press, by using suitably stamped moulds in the same manner.

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*) They are made by A. Reiche, Sheet Iron Works in Dresden-Plauen.

Chocolate eggs.

These are generally made hollow, unless they are very small, by pressing chocolate in two halves of an egg-shaped mould and then uniting the two parts. Another mode patented by Th. Berger of Hamburg*) seems less practical. A mould is made of soft sheet caoutchouc blown out; this is dipped into liquid chocolate and, after the adhering coating has hardened. the air is let out of the mould. The use of caoutchouc moulds would render this method too costly, since the alternation of temperature soon makes the caoutchouc unserviceable.

Various figures, fruit, animals, and other small objects.

Double moulds are used for making these objects in chocolate, sometimes the moulds consist of three or four parts; they are made either of sheet iron tinned, or, for more complicated forms, the moulds are cast in tin, but these latter are not so durable as those of tinned sheet iron with strong iron frames.

The several parts of the moulds, after having soft chocolate mass pressed into them, are put together and excess of material is removed by requisite pressure by the use of a press of the kind made by A. Reiche in Dresden, which will admit of a large number of moulds being placed in it at one time. By the use of such a press the moulds are protected from injury, and the objects moulded have a better appearance, as a result of the uniform as well as strong pressure exerted.

After cooling, the moulded objects are readily detached from the moulds and they only require to be scraped clean, or further ornamented as may be desired. That is done in various ways, for example by painting with coloured cacao butter.

Crumb Chocolate.

This term is applied to the small pieces of chocolate of truncated conical shape, with from 4 to 5 smooth surfaces. They are made by a machine specially constructed for the purpose by A. Reiche (No. 1550); it consists of a four cornered box with a removable bottom. Inside the box there is a false bottom, from 1 to 2 cm above the other bottom, which is fitted with a removable sheet iron plate, in which pentagonal holes are stamped. A knife can be introduced at one corner of the bottom of the box. After sufficient chocolate has been made to penetrate through the pentagonal holes by agitating the box on the table, the knife is rapidly drawn across the bottom and the box raised up. The sheet iron plate is then taken out, and by gently tapping one corner the small pieces of chocolate are shaken out.

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*) German patent No. 62,784.

Small tablets, sticks, fruit or figures filled with cream.

These are prepared by placing the cream contents in moulds of wood or sheet iron, dusted with flour, and then moulding round them chocolate that must contain sufficient cacao butter to be readily kept soft.

Formerly the moulds for this purpose were obtainable only from France, where the industry was represented only by the firm Létang in Paris; but since 1870 the German firm of Anton Reiche in Dresden-Plauen, already often mentioned, has succeeded in producing moulds of the kind which are everywhere in use. The moulds made by that firm answer all requirements; they are durable and in some instances executed with much artistic taste. Reiche also makes all kinds of small utensils employed in the preparation of cacao wares.

The shaking table.

The pasty chocolate mass spreads itself out spontaneously in the moulds; but in order to make it penetrate to all parts of the mould, and to get rid of any bubbles of air that may remain in it, the moulds, when filled with chocolate, are subjected to a sharp oscillatory motion.

That is effected by the shaking table, upon which trays containing a number of filled moulds are placed. The shaking tables now in use are of various construction, a typical form of which is represented by figure 45.

The movable slab a, fitted with an upright rim at its edges, has underneath two projecting pieces d, working against deeply toothed wheels e which revolve with the shaft b driven by an endless band on the pulley c. As the shaft revolves, the teeth of the wheels e act upon the projecting pieces fixed under the slab pushing them on one side, so as to raise the slab with a jerk until the ends of the teeth in contact with the projecting pieces pass over them, and the slab drops down as much as it has been raised. Each tooth of the wheels coming in contract with the projections repeats this motion of the slab causing it thus to oscillate up and down.

In order to stop the motion of the slab, the wheels can be thrown out of contact with the projections by a lever fitted at g, and without stopping the rotation of the shaft b.

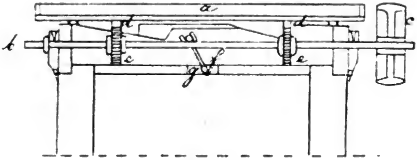

fig. 45.

Great improvements have been made in shaking tables, and those introduced by Lehmann are especially interesting from a mechanical point of view.

An old form of shaking table, that is still much in use is shown by figure 46. The oscillating motion is there produced by shaking wheels, underneath the slab, having 6 or 8 or more teeth. The slab is raised by contact with wedge shaped parts, then allowed to fall, the effect produced being greater or less in proportion as the moulds are large or small, heavy or light, and the material under treatment is hard or soft.

The noise caused by the oscillation of the slab and the jumping of the moulds is so considerable that a chocolate factory may be very objectionable, on that account, to its neighbours. For years attempts have therefore been made to construct shaking tables, so that they would not cause any greater noise than is inevitably the result of the shaking of the moulds. Pneumatic contrivances and caoutchouc were tried with very good results until a few years ago, when the shaking table patented by Lehmann, working without either of those means, was introduced and at once adopted in practice. A table of this construction is represented by figure 47, and in vertical section by figure 47a. The driving pulley a, communicates motion to the crank shaft b, the connecting road g of which works through the sliding piece e, lifting the slab of the table vertically in the collar h. The sliding piece e, also works against a connecting rod f fitted concentrically upon the crank shaft, so as to admit of regulating the height, to which the slab is raised.

The most recent improvement, and probably the most perfectly constructed shaking table, is that introduced by Lehmann and represented by figures 48 and 48a. It embodies all the latest improvements and is self lubricating, since permanent absence of noise, with a machine making 800 strokes per minute is to be expected only when the attendance is good. That consideration is the more important because the attendance of the shaking tables in the moulding room is in the hands of the girls working at those machines, who know little about the machines and do not take much interest in them. Moreover, in addition to self lubrication, screws and nuts are entirely done away with in this machine. By a special arrangement, the number of revolutions, in relation to the number of the elevations of the slab of the table, is reduced from 760 per minute to one fourth or to 190. Since the elevation of the slab can be regulated to zero, a loose pulley for shifting the driving belt is unnecessary; moreover, the driving shaft makes only a small number of revolutions, and the bearings work in oil. The round shaped upright serves to carry the frame i i, which works vertically and is con-

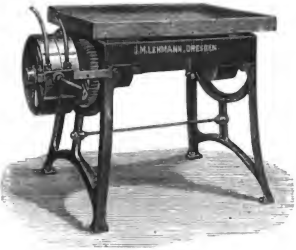
J.M.LEHMANN, DRESDEN.

fig. 46.

nected above with the slab of the table moving, at s, in a lubricating groove of large diameter and resting below upon

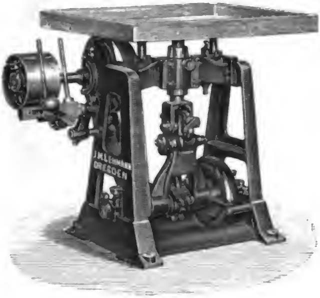

fig. 47.

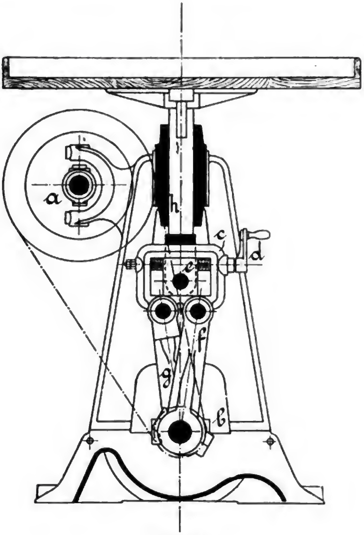

fig. 47a.

the pin m, the lubrication in both places being automatic. The sockets of the spindel n, attached to the upright, work into left

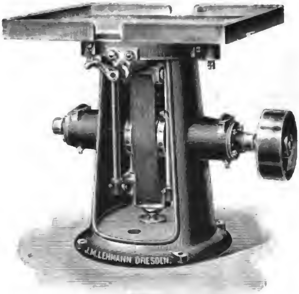

fig. 48.

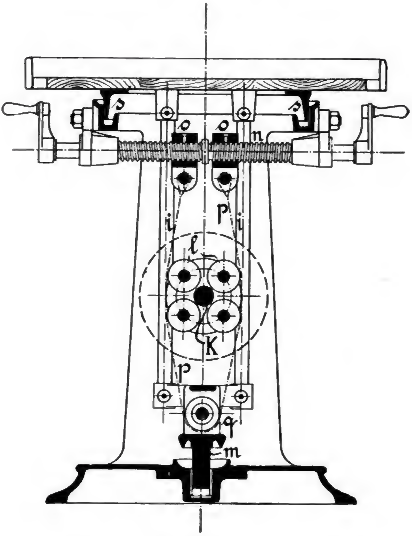

fig. 48a

and right screw threads at o o, to which points, are attached the ends of a broad leather belt p, passing over the roller g, by which the frame i is suspended. The driving pulley k, running in oil, carries four rollers l, which turn with and round the pulley k, so as to come into contact with the belt and press it outwards on both

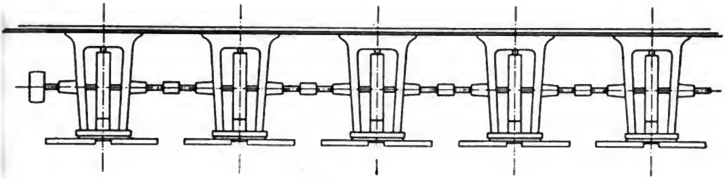

fig. 49.

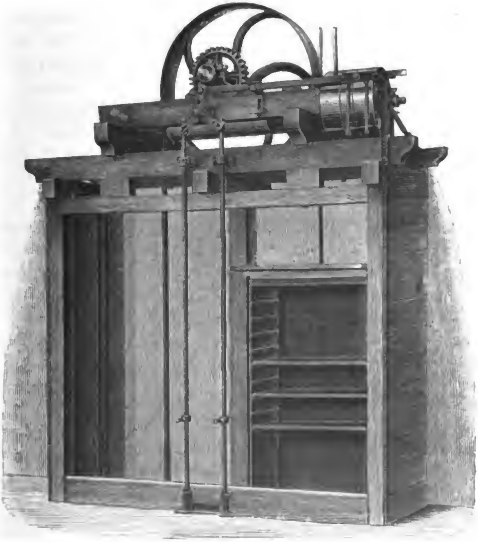

fig. 50.

sides, while at the same time, by shortening the belt vertically, raising up the frame i together with the slab of the table. In one revolution of the driving pulley, that is done four times, so that working with 190 revolutions per minute, the slab of the table is raised 760 times. According as the screws o o are moved to or from the centre, the vertical movement of the slab can be increased or decreased to a point at which the slab ceases to act, when the rollers l no longer touch the belt p. Under favorable local conditions, a number of such tables can be driven by one shaft so that only one pulley and one driving belt would be needed, though each table would work quite independently of the others. Such an arrangement is shown by figure 49. This shaking table, though only recently introduced, has been very generally adopted and it is especially well suited for the preparation of readily liquefiable sweetmeat chocolate. The gentle vibratory motion produced by this shaking table and its exact adjustability admit of the thinnest cakes being made of perfectly uniform thickness without any projections at their edges. Besides the shaking tables of this construction there are others made in such a way that whether the moulds are light or heavy, small or large, the slab of the table is always raised to the same height, the working of the slab being regulated by altering the number of revolutions. The manipulation of these tables is more difficult than that of tables constructed as above described, and probably, that is the reason they have not come much into use.

The moulded chocolate spread out on trays is transferred as rapidly as possible to the cooling chamber. The arrangement most suitable for that purpose is shown by figure 50, and it will be again referred to under the head of transport machines.

11. Cooling the chocolate.

Experience has shown that the more rapidly the moulded chocolate is cooled the finer is its texture and the more uniform is the appearance of the fractured surface. That is due to the formation of smaller crystals of the fat when the cooling is rapid, while in slow cooling larger crystals are formed and the fracture consequently becomes dull and greyish.

Formerly it was possible to distinguish chocolate made in summer from that made in winter by the more uniform appearance of the fracture that was, in the latter case, the result of more rapid cooling.

At present however, manufacturers are no longer dependent upon favorable atmospheric conditions in that respect, for by suitable arrangements it is now possible to produce, artificially, the reduced temperature requisite.

The most suitable cooling chamber is an underground space which should, however, be so situated as to be in convenient communication with the moulding room. The cheapest and most advantageous place for a cooling chamber is a cellar, if it be properly constructed and dry, as well as large enough to contain the quantity of chocolate made in one day's working. The best temperature to be kept up ranges from 8° to 10° C. Within those limits there is no danger of the chocolate being coated with moisture, or that it will acquire a coarse grained texture by lying too long. The following rules will serve for guidance in regard to this point:

Generally, chocolate presents the finest fracture when it has been fully levigated and when it contains a considerable amount of fat, provided that the fat present is only cacao butter. Those kinds which are not so well levigated, or have had some addition of foreign fat of higher melting point, show an inferior fracture. It is possible to obtain an equally vitreous fracture in a less cold cellar (16° C. and upwards) when the chocolate is moulded at a temperature corresponding to that of the cellar; to effect that, the chocolate should be moulded at a proportionally lower temperature the warmer the cellar is. The difference can be seen by the appearance of pale red spots on the surface. When it is desired to dispense with artificial cooling, the cellar should be as much as possible below the surface of the ground; it should also be of sufficient height, not less than 3 m. If the situation and height of the cellar be properly adjusted, the requisite area for disposing of a daily production amounting to 5000 kilos would be 400 sq. m. The cellar must be well ventilated and furnished with double windows, so placed as to open towards the north and east. Discharges of warm waste water, as well as steam pipes or furnaces should be kept as far distant from the cellar as possible. The internal arrangement of the cellar should be of such a nature that the whole of the chocolate to be cooled can be deposited upon the floor, since that is the place where cooling takes place most rapidly. With that object in view it is desirable to construct brickwork pillars about 25 cm high covered with white tiles. The passages are arranged between these pillars. The cellar should be entered by as few persons as possible and, therefore, the cooled cakes of chocolate should be taken at once, in the moulds, to an adjoining room to be turned out and passed on to the packing room and store.

Most of the existing factories, that have been established for any time (large and small) have had to adopt artificial means of cooling, because in most instances the quantity of chocolate to be cooled daily has, in course of time, increased tenfold. The machine rooms have been enlarged, the number of machines has also been increased, while the cooling cellar has remained in its formerly modest proportions. But those circumstances are not the only reasons for having recourse to artificial refrigeration, which is often necessary in consequence of the inconvenient situation of the cellar and the high underground water level.

In the application of artificial refrigeration in a chocolate factory it is not advisable to hasten the cooling of large quantities by producing too low a temperature in small chambers. The cakes of chocolate mass by that means come out of the moulds as hard as glass, but it is questionable whether the consumer using the chocolate many months afterwards, will make the same observation. Great care would have to be taken with such rapidly cooled chocolate, to pass it gradually through chambers of a medium temperature and thus prepare it for exposure in the packing rooms and warehouses. Even when employing artificial means for cooling, the reduction of the cellar temperature and cooling upon pillars is to be preferred to the more direct cooling upon a system of pipes, which after all is nothing else than a cooling upon ice, as may be in some instances the only alternative. Consequently, a well constructed cellar for cooling, furnished with a system of cooling pipes on the roof is perhaps the most advantageous arrangement, especially for large factories.

In carrying out artificial refrigeration various kinds of machines are used for reducing temperature, in which the desired effect is produced either directly by the condensation and evaporation of suitable materials, such as liquid carbonic acid, ammonia, sulphurous acid, or indirectly by making saline solutions (calcium chloride) cooled below the freezing point, circulate through a system of pipes fitted upon the roof or walls of the space to be cooled. As the cold liquid is forced by pumps through the pipes, it takes up heat from the air in contact with them, correspondingly reducing the temperature of the cooling chamber. One of the best arrangements for such artificial refrigeration is that constructed by Wegelin and Hübner at Halle a. S., in which carbonic acid is employed, and it has been found well adapted for use in chocolate factories. The accompanying illustrations figures 51 and 51 a represent an arrangement of that kind, which has been used for several years in the chocolate factory of Wesenberg & Son in Berlin.

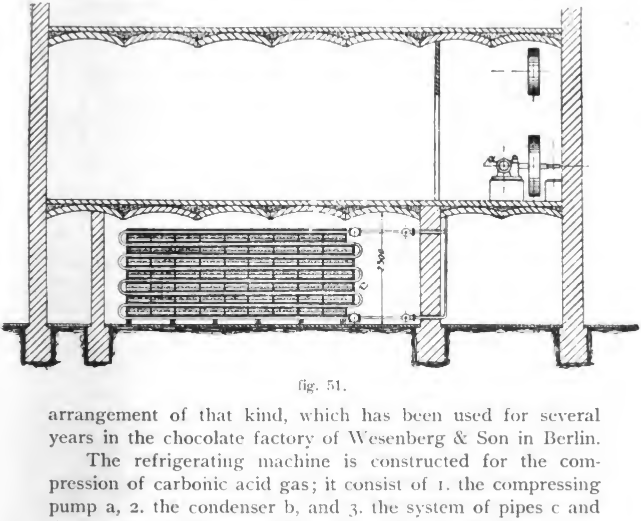

fig. 51.

The refrigerating machine is constructed for the compression of carbonic acid gas; it consist of 1. the compressing pump a, 2. the condenser b, and 3. the system of pipes c and d, that constitute the refrigerator. The coil of pipes in the refrigerator is connected at one extremity with the compressing pump and at the other extremity with the condenser. Liquid carbonic acid passes from the condenser into the coil of pipes and is there evaporated. The heat necessary for that change is withdrawn, either directly or indirectly, from the cooling chamber and from the chocolate placed in it, until the desired reduction of temperature is brought about.

The compressing pump a is a peculiarly constructed suction and pressure pump, it draws out of the refrigerating pipes

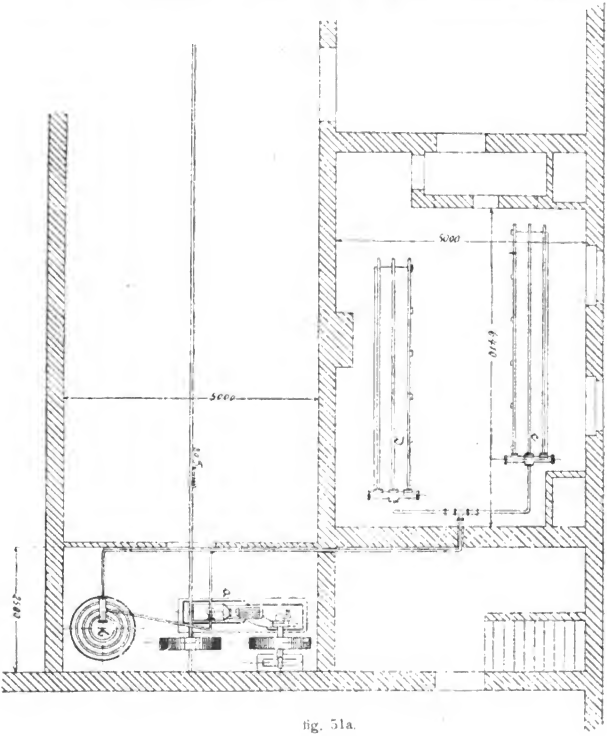

fig. 51a.

the vaporized carbonic acid by which they have been cooled and then subjects it to a pressure which helps to effect its reconversion into the liquid state.

The condenser b consists of a coil of pipes over which a current of cold water is kept flowing and the compressed carbonic acid vapour, passing from the compresser into these pipes, is there cooled and condensed by the surrounding water, so as to be transferred back to the refrigerator through a valve fitted to it for that purpose. The outer vessel of the condenser is constructed of cast-iron, in one piece with the compressor frame. These cooling arrangements are constructed either with or without mechanical ventilators. In the figures 51 and 51a the compressing pump and condenser are represented as placed on the ground floor, while the refrigerator is situated in the cellar space lying beside them and at a lower level, in such a manner that both the systems of cooling pipes are not situated upon the roof of the cellar, but run along it at regular distances parallel to the side walls of the cellar. The compresser and condenser form one apparatus and the former is driven by a steam machine.

In the cooling cellar, the refrigerator is generally fixed to the walls in such a way that the warm chocolate, taken into the cellar, can be at once placed upon the stages formed by the system of cooling pipes. But there is some advantage in having the system of cooling pipes fitted along the roof of the cellar. One end of the coil communicates with the condenser, the other end is connected with the compressing pump. When the apparatus is working, the carbonic acid flows out of the condenser into the coil of pipes, vaporizing there and reducing the temperature of the cellar in which they are situated, until the chocolate placed in it has the desired low temperature. The carbonic acid vaporized in the coil of pipes is then drawn into the compressing pump and forced into the pipes of the condenser, where it is liquefied and is again ready for being transferred to the coil of pipes in the cooling cellar, to renew the work of refrigeration.

The accompanying table of dimensions and working capacities for cooling cellar arrangements will furnish an idea as to their efficacy. (Table see page 162.)

Another method of cooling,*) that is carried out in France consists in placing the moulds, containing cakes of chocolate, upon a travelling belt running horizontally through the whole length of the cooling chamber. The requisite reduction of temperature is effected by apparatus similar to that described above in Wegelin & Hübner's arrangement. The liquefied car-

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*) Villon-Guichard, Dictionnaire de Chimie industrielle. Vol. I Chocolat.

Number of the cooling machine (Wegelin and Hübner)	**Working** capacity, expressed in calories per hour approximative	Cooling of chamber to 3° C = 37 4° F.												Space occupied by Refrigerator in millimetres approximative		
		Temperate climates						Tropical climates								
		Capacity of chamber in cubicmetres				**Power required** (Horse power) approximative	**Con-sumption of water** ex-pressed in litres per hour at about + 10° C.	Capacity of chamber in cubicmetres				**Power required** (Horse power) approximative	**Con-sumption of water** ex-pressed in litres per hour at about + 10° C.			
		Situation of chamber						Situation of chamber								
		under ground		above ground				under ground		above ground						
		well isolated	not isolated	well isolated	not isolated			well isolated	not isolated	well isolated	not isolated			Length	Breadth	Height
0 I	750	20	5	11	3	$^{3}/_{4}$	150	7	2	6	2	1	750	950	450	1300
0 III	1600	35	8,5	19	4	$1^{1}/_{4}$	250	18	4	11	3	$1^{1}/_{2}$	1000	1050	600	1300
0 V	2200	52	12,5	30	6	$1^{1}/_{2}$	350	27	6	16	5	2	1500	1400	1300	1500
0 VII	2800	70	18	40	10	$1^{3}/_{4}$	500	37	9	23	6	$2^{3}/_{4}$	1750	1500	1400	1500
0 IX	3500	90	25	50	13	$2^{1}/_{4}$	650	50	10	34	7	$3^{1}/_{2}$	2000	1600	1500	1500
0 X	5500	154	43	86	23	$2^{3}/_{4}$	800	85	18	58	12	$4^{1}/_{2}$	3100	1700	1600	1800
0 XI	7500	220	65	135	33	$3^{1}/_{2}$	1000	132	32	95	20	$5^{1}/_{2}$	3800	1800	1700	1800
0 XII	11000	320	76	200	48	$4^{1}/_{2}$	1500	193	47	140	30	7	5000	1900	1800	1800
0 XIII	17500	520	160	320	90	$6^{1}/_{2}$	2500	312	88	216	57	9	8000	2000	1900	1800

bonic acid flows through a system of pipes fitted to the roof of the cooling chamber, producing by its vaporization the necessary cooling and then it passes back to the refrigerating machine. Circulation of the air in the cooling chamber is provided for by a suitable ventilator under the pipes of the cooling system, gutters being fixed to carry away any water condensing upon their surfaces and prevent it from falling upon the chocolate. The travelling belt passes along so slowly that the moulds, containing chocolate, placed upon it at one end, take from ten to fifteen minutes in passing to the other end where they are taken off and carried to the packing rooms.

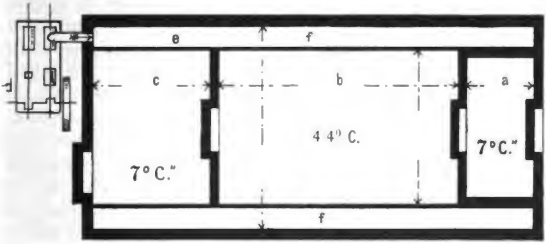

fig. 52.

Among other refrigerating machines, worthy of notice, are those made by Douane in Paris which are in great demand with French chocolate makers. The refrigerating agent used by Douane is methyl chloride; the cooling arrangement is very simple, inexpensive and does not cause any complication in the handling of the trays coming from the shaking tables.

A fourth cooling arrangement that works very well is constructed by T. & W. Cole of the Park road iron Works, London E. figure 52, represents a plan of this arrangement, which has the great advantage of providing for the exclusion of

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a) Ante-Room 7° C;
b) Cooling Chamber 4·4° C;
c) Store Room for cooled chocolate 7° C;
d) Refrigerator;
e) Inlet for cold air;
f) Travelling stage for the chocolate.

moisture from the cooling chamber. Refrigeration is effected, by means of Cole's Arctic-Patent Dry Cold Air machines, by compressing atmospheric air and then allowing it to expand, after being cooled by water and having moisture removed by suitable arrangements. The machine is of very solid construction; it works at a pressure of from 70 to 80 atmospheres and drives the dry cooled air through a system fitted in the cooling chamber where the chocolate is spread out, either on portable trucks or on a travelling belt, so that it remains in the chamber long enough to become perfectly cold. The system of cooling can be changed in various ways. The sudden removal of the cold chocolate into another chamber where the air is moist, would be attended with a deposition of water upon the goods. For that reason the goods are first transferred, for a short time, to a warm chamber (ante-room) where they acquire a temperature at which no deposition of moisture can take place. The chief advantage of this arrangement is that it furnishes dry cold air economically, both in summer and also in a moist climate. Cole guarantees that this machine will effect a refrigeration of 5° C.; according to the statement of Messrs. Negretti and Zambra the cooled air contains only 40% of moisture. The cold air from one of these machines can be led, by a well insulated run of pipes, to any part of a factory and thus be made available for cooling purpose in different places.

12. Preparation of chocolate lozenges and pastilles.

These articles are generally made with cacao mass, sugar and spices. Formerly they were made by placing the soft chocolate mass upon a stone slab, furnished with a rim of uniform height, and rolling out the mass to the required thickness which was regulated by the rim at the edges of the slab. The lozenges were punched out of the rolled out layer of chocolate by means of a cutter. After allowing the mass to cool, the lozenges were detached from the remaining portions which were then rolled out for a repetition of the same process.

Pastilles, on the surface of which impressions of various kinds such as the name of a firm etc. are required, may also be made by placing the soft chocolate mass upon slabs in which depressions are stamped that will produce the required device on the surface of the pastilles. In order to make the chocolate mass fit into the depressions a roller is used and the superfluous material is removed with a knife.

Pastilles of this kind are rendered perfectly sharp, in the moulding, only by subjecting them before cooling to the described manipulation on the shaking table.

At the present time, chocolate lozenges and pastilles are generally made in the two forms of apparatus constructed by A. Reiche of Dresden-Plauen.

In the first of these machines, represented by figure 53, the chocolate mass is made to penetrate through holes in a plate until small lumps of it project upon a slab beneath. After sufficient chocolate has passed through the holes, the box is raised on its hinge and the pieces of chocolate left upon the slab. By means of gentle shaking, these pieces take the required form and they are then cooled and detached. The coating of lozenges with coloured sugar is effected by passing them, together with the plate to which they adhere, through a box containing the sugar dust.

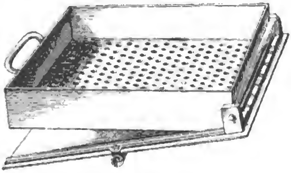
fig. 53.

By means of the machine, No. 3668, represented by figure 54a—f, which is made by A. Reiche, chocolate lozenges of the most diverse size can be prepared very rapidly and with great advantage. The chocolate mass is pressed through perforations in a metal plate and otherwise treated in the manner already described.

In working this machine it must first be sufficiently warmed, then partially filled with chocolate mass of the proper consistence. Before pressing down the plunger, worked by a screw, a metal plate is laid upon the chocolate to prevent contact with the plunger. By slight pressure, the chocolate mass is forced through the perforations, according to the required size of the lozenges, but the plunger must not be screwed down further. This will admit of the plate on which the lozenges rest, being drawn out and another plate inserted.

This machine requires to be provided with the ordinary perforated plates f, of which there are three of different sizes, for each machine, as shown by the figures a, b, c, also the plates d and e for making the perforated confections used for Christmas trees. These plates are supplied with designs of various kinds for making confections of two sizes. A third plate is supplied for making chocolate Croquettes.

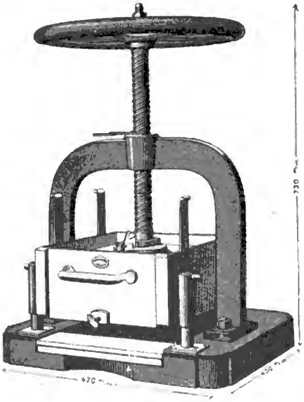

fig. 54.

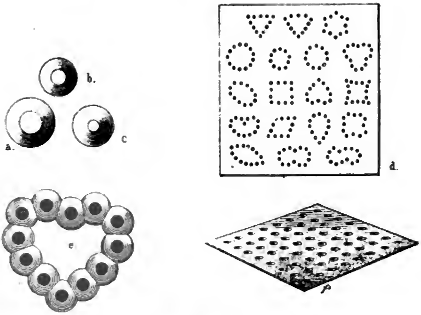

fig. 54a—f.

In order to be able to use this machine some practice is required. But any capable workman is soon able to turn out with this machine ten times as much as can be made with the ordinary lozenge machine.*)

13. Preparation of coated goods, pralinés etc.

The coated chocolate preparations are now especially esteemed and within recent years the consumption of pralinés, as well as of the cheaper forms with imitative contents, has increased very considerably.

The name praliné (properly pronounced Prahlin) has been applied to almonds coated with sugar, and it originates from a cook of the Marshal du Plessis, whose name was Pralins; in the time of Louis XIV., he was the first to make these sweetmeats. At the present time, pralinés are sweetmeats of various forms consisting of sugar, marmelade, cream, nut-paste etc., enveloped in chocolate. The special formulæ, by which the contents of different kinds of pralinés are prepared, belong to the art of the confectioner and they do not require to be dealt with in this place.

The substances used are known as fondants. Formerly the sugar, sufficiently boiled, was worked upon a slab with a spatula, an operation that was laborious and difficult to manage, especially towards the end. In consequence of the increased demand for such preparations, machines have now been introduced for carrying out the operation. Such a machine constructed by Lehmann is represented by figure 55.

The bed plate as well as all the working parts of the machine are constructed of stout copper plate. The working parts admit of being raised by means of the wheel above and they remain fixed while the bed plate is in motion. That is cooled internally by water issuing in fine jets from a rose, so that the cooling to be effected can be easily regulated. The machine is capable of working up pure fondant without addition of syrup, as well as that made with syrup. The boiled sugar is poured out on the bed plate of the machine, and according to the addition of syrup, it may be so far cooled, within the space of half an hour, that the machine can be set in motion, while the working parts are gradually lowered down to the bed plate. When pure sugar is used, the fondant is finished within six minutes, but when syrup is added a longer time is required. The fondant is then transferred to the moulds, lined with starch powder, these are taken to the drying room, where they remain until they can be turned out and transferred to the dusting machine, represented by figure 56. That consists of a casing in the upper part of which the goods, spread out on boards, are placed upon a travelling band and subjected to a powerful blast of air; they are passed through this machine several times, according to their particular nature.

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*) The machine works without any noise and delivers excellent products. If lozenges, with the name of a firm or any other device, are to be made, the corresponding impressions must be stamped in the plate on which the chocolate is received, after being forced through the perforations.

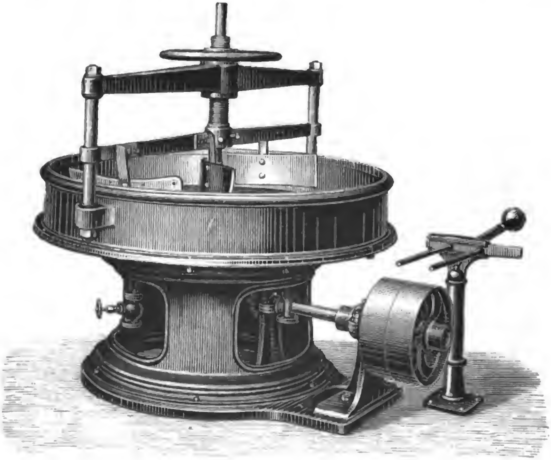

fig. 55.

Sweetmeats with liqueur, as well as those with nut-paste, (nougats) can also be made in this machine.

The sweetmeats are then dipped into liquefied chocolate to coat them with a layer of that material. The chocolate mass employed for that purpose must contain more cacao-butter (up to 15 %) than ordinary chocolate, to admit of being kept soft long enough for continuous working.*) The requisite large amount of cacao butter is one of the chief causes of the increase in the price of that article.

For mixing the couverture mass (chocolate mass and cacao butter) specially constructed machines, made by Lehmann may be used. (fig. 57.) These are furnished with heating and cooling arrangements, so that the material can be at once rendered fit for further operations.

The dipping of pralinés for the purpose of coating them was formerly carried out by means of a fork. That is to say, the pieces of nucleus material were dropped into the coating material and then taken out by the fork and laid upon metal plates. Various kinds of ornamentation were carried out in the same manner. In the preparation of the higher priced coated fondants the same practice is still adopted, although this manipulation requires very skilful workmen, and it adds very considerably to the cost of production. For articles of

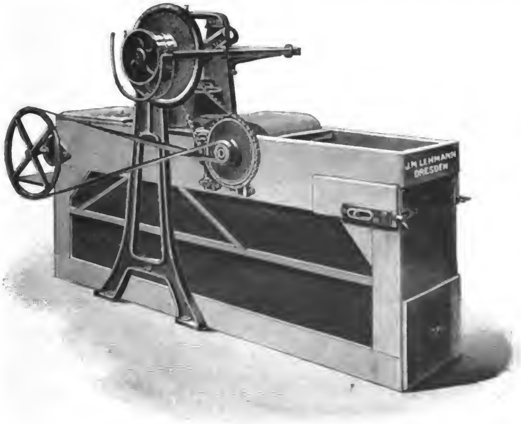

fig. 56.

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*) Coatings have the following composition: Sugar 50 %, fat from 30 to 35 %, Cacao mass without fat from 20 to 15 %, some part of this latter ingredient being replaced by almond meal, especially in Belgium. When that is done the iodine number of the fat is from 41 to 42.

more general consumption, whether ornamented or not, machines have been introduced for the purpose, within recent years, and some of them work very well. Two of that kind, which fully answer the purpose for which they are intended are here described, but the more complicated and very expensive machines of that kind will not be noticed.

The first method of coating fondants, patented by A. Reiche of Dresden-Plauen, is not based on mechanical arrangements, but a series of small appliances are used, which are represented by figures 58 to 60a. The jacketted casing a, figure 58, contains water and into it the pan containing the coating material can be placed: that is kept in a liquid condition by heating the water in the jacket by spirit lamps or gas jets underneath. The adjoining vessel b is closed on all sides, and is also filled with water, kept warm in the same manner; it serves for the

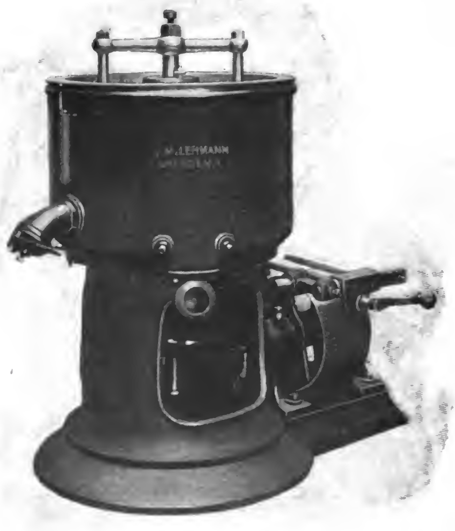


fig. 57.

preparatory warming of the objects to be coated, which are spread out upon a wire net work and for that purpose two of these wire frames can be hung upon hooks inside the box. The mass dropping from the wire frame is conveyed into the covering box a, by means of a sheet of metal placed above it; c serves as an apparatus for turning, and it is shown on a larger scale by figure 59.

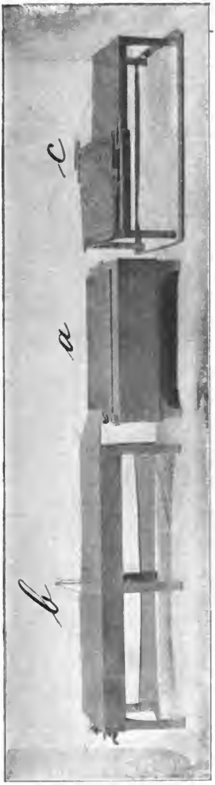


fig. 58.

The illustrations h and i, fig. 60, show the transverse section and upper view of the wire frames which serve for receiving cylindrical or conical sweetmeats as may be required.

The construction of both kinds of frames will be seen from L and M in figure 60a.

The meshes of the wire frames are adapted to the size of the sweetmeats to be coated.

In coating sweetmeats, the procedure is as follows; the sweetmeats to be coated are placed in the wire frames and when one of them is filled, it is covered with the fine meshed frame K, as shown in figures 60 and 60 a at K and N.

Both the frames are then taken together by their handles and lowered into the liquid covering material in the vessel a, fig. 58, then taken out so as to drain off superfluous material. The frames are then put upon the mechanism C, shown in fig. 58 and 59, the upper wire frame is removed and replaced by a sheet of paper upon which a metal plate is laid. By turning to the other side and taking away the moulding, the coated objects will be left on the metal plate at regular distances apart, a condition that is necessary to prevent the sweetmeats running together.

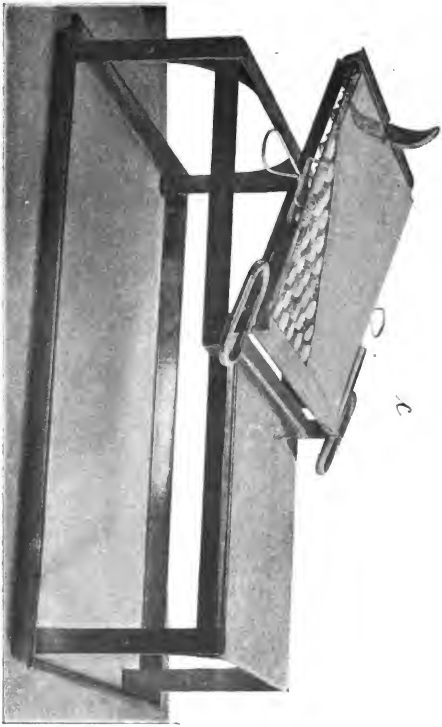


fig. 59.

Beans and rings are only half dipped, and, after cooling, the other halves in the same way; the use of the wire frame as a cover being in this case unnecessary. The frame K after being dipped, in making cylindrical or conical shaped articles, is at once placed upon the warming apparatus, to prevent cooling and abstraction of heat from the coating material when it is again dipped.

The preparation of pralinés can be very easily carried out in the new dipping machine constructed by Lehmann and represented by figures 61 and 61 a, b.

In that machine all the parts can be worked by hand; only the knocking and stirring arrangements are furnished with fast and loose pulleys. Upon two closets rest two supports of the nature of rails. The left hand portion serves for conveying to the dipping apparatus, which is placed in the middle and can be worked by four girls who drop the sweetmeats into the suitably shaped wire frames. These frames are made like those of Reiche, but without handles and they are moved by hand along the rails. When a frame is filled it is passed into a cage in which it is dipped into the coating material by means of the crank 3. The covering wire frame, which keeps the sweetmeats from floating, is movable and can be fitted on the dipping

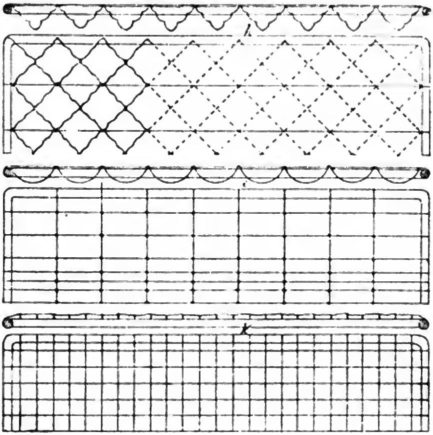


fig. 60.

frame when required. After the dipping frame has been raised up a knocking arrangement is set in motion, by means of which the superfluous chocolate is shaken off; the frame containing sweetmeats is then passed on to the right hand side to an apparatus (4—6) at one side of which 5 there is a plate, with a sheet of paper on it, upon which the sweetmeats can be placed by working the moving parts 5 and 6 of the machine. (Comp. fig. 59c and page 171 and 172.)

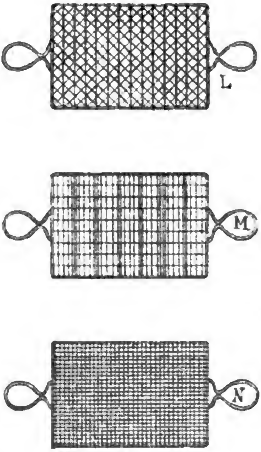


fig. 60a.

The plate, on which the sweetmeats are spread out, is then transferred to the cooling chamber or to shelves, placed near to the machine which must not be in a place that is over warm. The sweetmeats will show the configuration of the frame work, and, if requisite, further decorations can then be applied. In order to produce half dipped articles or such as are not coated at the bottom, an appliance is fitted to the toothed rod at 7, by which the frame can be prevented from dipping below a certain point. The box containing the coating material stands in casing,

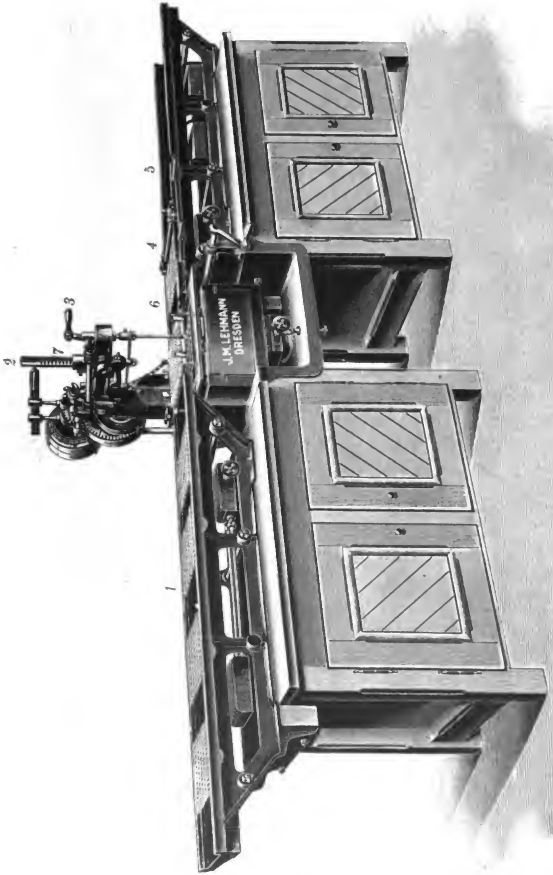
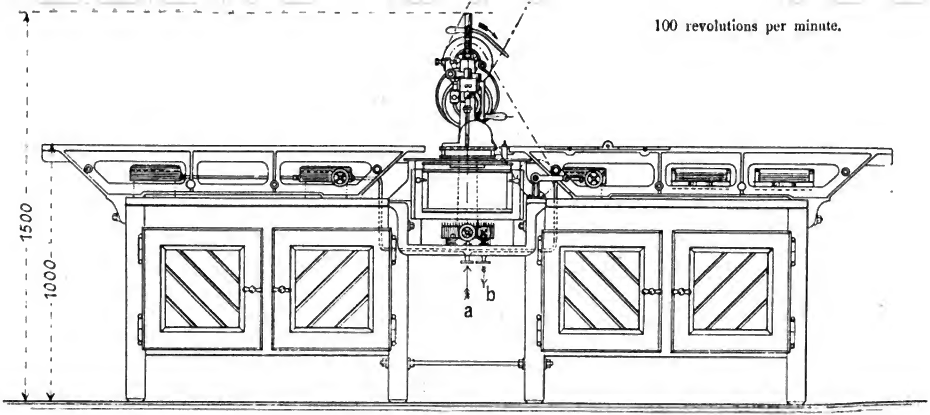


fig. 61.



a) Inlet for steam. b. Outlet for steam.

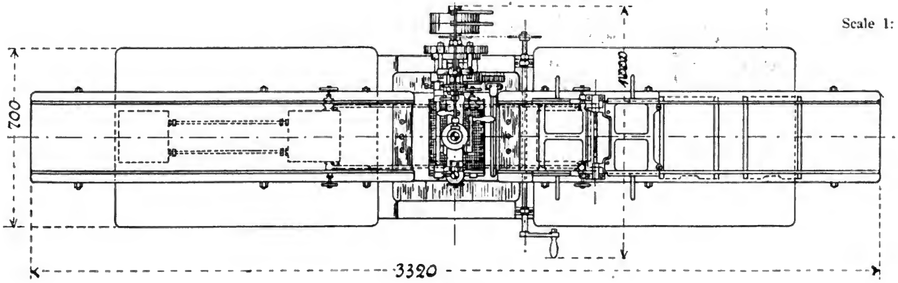


fig. 61 b.

surrounded with water, which can be heated by steam and it is fitted with a thermometer for regulating the temperature. The box containing the covering material can be withdrawn at the front and replaced by another. The whole of the left side of the machine has to be kept warm by steam as well as the apparatus 4—6 on the right side. When the wire work frames are done with on the right hand side, they are at once transferred to the other side to be filled again, so that for each design no more than five wire frames are requisite.

This machine is constructed of two sizes: one receives a wire frame of 280×200 mm and is used chiefly for articles resembling pralinés, while the other size receives frames of 280×400 and is therefore applicable for such articles as well as for larger ones, such as biscuits, waffles, cakes etc. The daily turn out of each a machine varies, according to the service by two, three or more persons and also according to the weight of the articles produced, from 300 to 600 kilos.

X. Manufacture of cacao powder and soluble cacao.

The relatively large amount of fat in cacao renders it unsuitable for use by persons suffering from affections of the stomach, and that circumstance has given rise to a demand for a preparation of cacao containing less fat and having the other organic constituents so modified as to be readily digested and absorbed by the stomach or intestine. In addition to that desideratum, a further object may have been that of rendering cacao readily miscible with warm water and thus capable of being conveniently used. To attain that end it appeared most advantageous to powder the cacao and partial abstraction of the fat is necessary to allow that to be done. In German trade a preparation (known as "Cacogna"), has long been met with, in which the fat is reduced to 20 or 25 %. Prior to that, the problem had been dealt with in Holland where C. J. van Houten, the founder of the firm J. C. van Houten & Zoon in Weesp, was the first to undertake the separation of fat from cacao: at the same time, he made experiments as to the effect of treating cacao with chemical agents, so as to render it more readily miscible with water and more suitable for use by sick persons. After the demand for the Dutch "soluble" cacao had become considerable, especially in England, Holland and Germany, manufacturers in Germany and Switzerland turned their attention to that branch of the industry. The consumption of cacao known as "soluble" has considerably increased within recent years, so that the production of that article is carried on to an extent almost equal to that of chocolate.

1. Methods of rendering cacao soluble.

The "solubility", which is at the present time so largely a desideratum in connection with cacao powder, is a characteristic that is not correctly represented by that term, but is more of the nature of an alteration of texture by the opening up or partial disintegration of the tissues of cacao, the effect of which is to render the material capable of suspension in liquids such as water or milk. The indication of being in that state is afforded by the absence of any considerable deposit, when cacao is mixed with boiling water and left at rest for a short time. The more the particles remain suspended in the liquid, instead of settling to the bottom, the greater is the appreciation of it.

To give cacao this character, it is subjected to treatment either in the raw or roasted state and either without removal of the fat, or after the fat has been partially extracted:

a) with water and heat, with or without pressure,

b) with alkalies such as potassium or sodium carbonate, magnesium carbonate (Dutch method), solution of ammonia, or ammonium carbonate (German method).

The principal chemical and physical effects produced by these agents consist in communicating to the particles of cellulose such a condition, that when mixed with liquids they sink to the bottom less readily, than when the cacao has not been so treated; at the same time the acids naturally present are neutralized and the cacao red is partially altered, a result that may be regarded as less desirable, in so far as it may affect the aroma, which is due to cacao red. When steam is employed for the purpose the starch is rendered soluble and an acid fermentation is also set up.

For the reasons here stated, the treatment with steam is not very desirable and, at the present time, it is practised only in rare instances; treatment with alkalies being now almost exclusively adopted, according to modifications which will be described in their proper place.

The secrecy with which the process of rendering cacao soluble, was surrounded some fifteen years ago, has in the course of time been dispelled, so that the methods practised can be treated of without reserve, although it must be admitted, that some details of the process, as carried out by certain firms, are still kept as secret as formerly.

In the preparation of "soluble" cacao, the following are in general the different stages of the process:

1. Cleansing and picking the raw beans,
2. Roasting, shelling, crushing and grinding,
3. Treatment with alkalies, or with water,
4. Removal of fat,
5. Powdering.

That sequence, so far as relates to existing knowledge of the operation, is subject to some variation as to the treatment with alkalies, which may be carried out, either:

1. Before the roasting, or
2. At the roasting,
3. Before the pressing, after the roasting, shelling, crushing and trituration in a triple machine, and
4. After the pressing.

The cleansing and picking of the raw beans, the whole treatment of the raw material, is in all instances carried out on the same principles, and by means of the same machines that have already been described.

According to some methods of working, those operations are immediately followed by treatment with alkalies.

C. Staehle *) renders cacao soluble by subjecting the beans to the action of steam and ammonia at a temperature below 100° C. During the subsequent roasting at a temperature of 130° C., the ammonia that has been used is supposed to be again converted into vapour and the aroma to be developed.

Pieper **) moistens the raw beans wtih water, to which alkali has been added, so as to neutralize any acid present, the beans are then allowed to ferment before being dried and roasted. The fermentation is thought to render albuminous constituents more digestible and to give the beans a fine red colour. This method is therefore a subsequent fermentation with the aid of alkalies. From a scientific point of view, none of the advantages claimed by Pieper for this method can be regarded as really existing, except that of improvement in the colour, and that can be effected by suitable treatment with water alone.

Passing now to the processes in which fixed alkalies — potassium, sodium or magnesium carbonate — are used in the manner invented by the Dutch and still followed by them: the cleansed beans are first of all slightly kiln dried in order to facilitate the removal of the shells. The partially roasted cacao has then to be crushed into very small fragments, so that the separation of the shells may be effected as perfectly as possible;

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*) German-Patent No. 666,606.

**) German-Patent No. 74,260 3rd Septr. 1893.

as a rule, the less the cacao is roasted, the smaller it must be broken up. The loss attending the operation is greater the smaller the fragments into which the cacao is crushed. The cacao thus prepared, is then sprinkled with a water solution of alkali. Generally potassium carbonate is used, dissolved in threefold its quantity of water and in the proportion of from 1·5 to 2 percent, or at the utmost 3 percent of the intended preparation, when the fat has been removed. Some manufacturers substitute sodium carbonate, or a mixture of it with magnesium carbonate. In case too much alkali is used, tartaric acid may be added (in the proportion of 150 grammes per 100 kilos of beans) for the purpose of counteracting the effect of the excess, which might give the finished product a disagreeable taste that would not be the case when the alkali was converted into tartrate. The tartaric acid solution (150 grammes in 1 or 2 litres of water) should be added during the roasting and shortly before the final roasting, care being taken that the water, so added, is entirely driven off before the cacao is taken from the roasting drum After the cacao has been uniformly impregnated with alkali, it is then finally roasted. In that operation, the trial of test samples, drawn from time to time to observe the smell and taste, is of very much greater importance than in the roasting of cacao for chocolate making; it is also much more a matter of judgment to determine when the requisite degree of roasting has been effected. This final roasting must be carried out with a very gentle fire, since the cacao is broken small and free from husk. Lehmann's large roasters (figure 18) are best adapted for this roasting operation, because overheating is not so likely to occur, even when operating with large quantities of beans; also because the roasting chamber is easily accessible and, by reason of its construction, thorough cleansing can be carried out to the extent that is necessary. Crushed beans mixed with water are much more liable to be charred than the raw beans in the shell; consequently, if thorough cleansing of the roasting apparatus cannot be effected, as in the case of globular roasters, any particles of a charge left in the roaster would be overheated in the following operation and, probably, carbonised so as to give the entire charge a more or less objectionable taste.

If it should appear necessary, the cacao may then be crushed once more, before it is passed into the mill where the fine grinding is carried out: it is then placed in receptacles to be kept warm (figure 28 page 123) until the further operation of extracting fat can be carried out. The fine grinding is required in order that the material, from which fat has been separated, may, at a later stage, be easily sifted and, when mixed with water, not deposit very much.

2. Expression of cacao fat.

For this operation, which is of considerable importance in connection with the manufacture of soluble cacao, hydraulic presses are now used almost exclusively; but in this part of the preparation of cacao, there have been various changes in the course of time.

Mitscherlich mentions on the authority of Macquer,*) that cacao butter was formerly obtained by boiling the crushed beans with water and then purifying the fat collecting on the surface after cooling. According to Desprez,*) roasted and decorticated beans were finely powdered, spread in a layer upon ticking stretched over the surface of boiling water, so that the powder was permeated by steam; it was then subjected to pressure in linen bags at a temperature of 100° C. The cacao butter obtained in that way, amounted to as much as 50%. Subsequently hydraulic presses, capable of being heated, were employed for the purpose, the mass to be pressed being packed in cloths and bags. For that purpose, the cacao powder was mixed with sufficient water to form a stiff paste which could be easily pressed, but that method had the disadvantage, that the cacao was liable to become mouldy when kept and to acquire a grey colour. To avoid those defects presses are now constructed of such a nature that the liquefied cacao can be run direct into the press receptacles. A press of that kind worked by hydraulic power is represented by figure 62.

That press exerts with 75 atmospheres a gross-pressure of 60 thousand kilos upon the cacao. In its construction it resembles the presses used for extracting oil from seeds, but in operating upon cacao, the cups of the press must be close fitting both above and below the pressed material, in order to prevent the liquid cacao from passing through, a precaution, that is not requisite in pressing oil seeds. The closing of the press cups is effected by cranks; they can be heated above and below; four of them are fitted one above the other, and each one can be drawn out on rails for charging. When the press is working the cups and the piston below fit together, working into each other after the manner of a telescope. The pump supplying water for hydraulic pressure is fixed to the press; it works automatically, increasing the pressure as the fat exudes and maintaining it any required degree. With this press, the fat of cacao can be readily expressed to the extent of 66 % or more of the total amount. When the heat applied during pressing is too great the fat expressed is of a dull gray white colour. With moderate attention of experienced workmen,

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*) Mitscherlich, page 58.

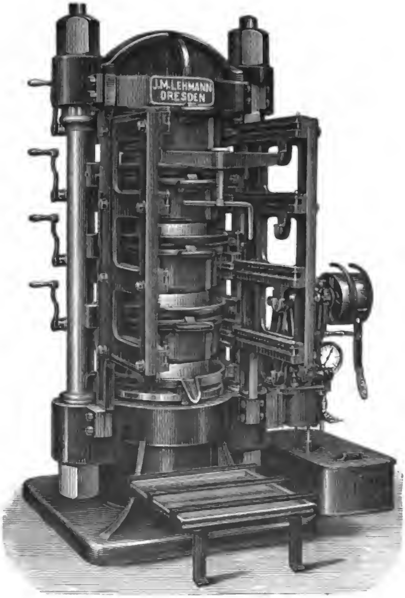

fig. 62.

the fat can generally be obtained quite clear, as it has to pass through horse hair bags, or camel hair bags of 15 mm thickness. But in pressing, sufficient care is not always taken and some cacao may escape with the fat, especially if the pressure is increased too rapidly at first. For the ordinary uses of such butter in the manufacture, that circumstance is not of much account, since the good appearance of the butter has to be considered only when it is to be sold; in that case, filtering may be necessary. In most factories, the butter is melted and allowed to settle until the upper portion is clear, when it is drawn off from the sediment. If filtration is requisite, an ordinary butter filter may be used of the kind common in Holland. It consists essentially of a number of long flannel bags.

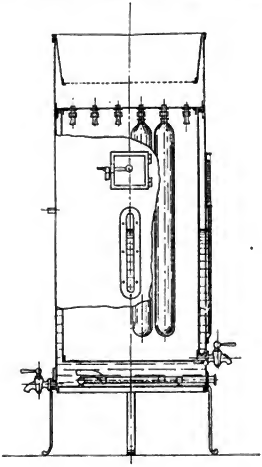

fig. 63.

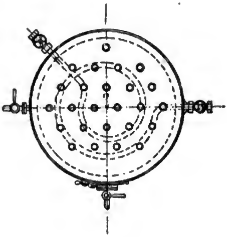

fig. 63a.

The firm of Volkmar Hänig & Co. in Dresden has recently introduced a filtering apparatus for cacao butter, which can be obtained through the firm of J. H. Lehmann, it is represented by figures 63 and 63a. After the melted butter has passed through a hair sieve at the upper part of the apparatus, for separation of coarse particles of wood, etc., it runs into the hanging filter bags, which admit of being changed for cleaning, and collects in the cylindrical vessel from which it can be drawn by the tap at the bottom. A gauge glass shows the level of the fat, and the apparatus is surrounded by a water jacket that can be heated by the steam pipe below. A thermometer is fitted at the side.

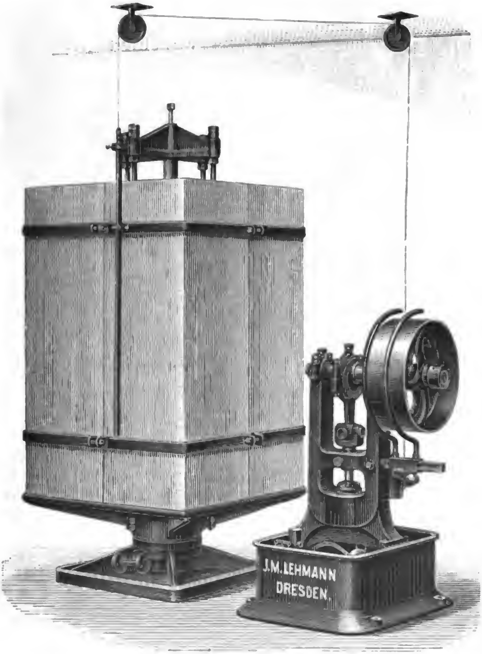

fig. 64.

When several presses are used for cacao butter, they can be conveniently worked by means of an accumulator of the kind represented by figure 64. The pump maintains the water in the accumulator at a pressure of 75 atmospheres, so that each press only requires to be fitted with a suitable inlet valve. Each valve is connected with a manometer which indicates

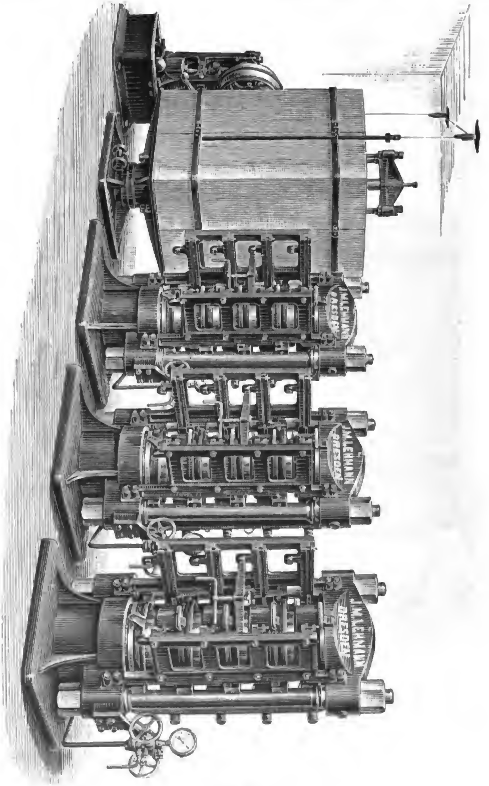

fig. 65.

the working pressure in the press. This plan of working with an accumulator is very much more advantageous than the ordinary arrangement, since the required pressure is at once exerted, when the inlet valve is opened. Figure 65 represents such an arrangement of three presses with an accumulator. These presses are constructed by the firm of Lehmann.

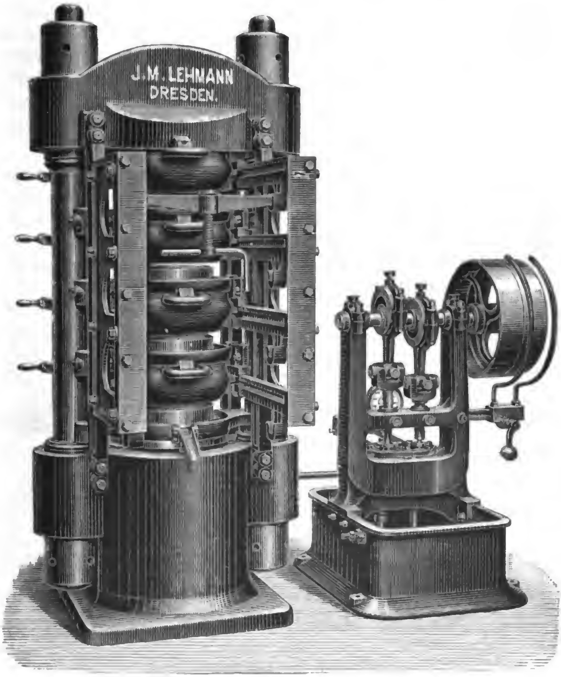

fig. 66.

Cacao, from which the fat has been partially expressed, tastes the more agreeable the less the fat has been removed: to that circumstance is to be attributed the excellence of soluble cacao prepared by the Dutch method, which still contains from 26 to 33 percent of fat; so that, assuming the average amount of fat in cacao to be 50%, only from 34 to 48% of it has been separated. If the removal of fat is carried further than that, the cacao is rendered more readily miscible but the aroma is deteriorated as well as the taste. Removal of the fat to the extent of 66% may be taken as the utmost that is admissible, if the cacao powder is to be of good quality and aromatic. The high price of cacao butter is however an inducement to extract a larger proportion notwithstanding the reduction of the quality of the cacao powder. For producing material retaining only a small amount of fat, much more powerful presses must be employed, and figure 66 represents a press of the kind constructed by Lehmann.

That press exerts, with 300 atmospheres, a total pressure of a quarter of a million kilos upon the cacao and it is capable of separating the fat to the extent of 85%. The construction of the press is exactly the same as that represented by figure 62, except that the pump has two pistons: it works automatically, that is to say, the greater part of the water is forced into the press by the larger piston up to about 5 atmospheres, and then the smaller piston of 16 mm diameter is worked until a pressure of 300 atmospheres is reached. Such a press is chiefly useful for pressing fat from damaged cacao beans that are of value only for their fat. But even with such a press, entire separation of the fat from cacao is impracticable and that result can only be effected by means of solvents such as petroleum spirit, ether, etc. provided the material to be extracted has been ground to a sufficiently fine powder.

After expressing the fat, the pressed cake of cacao is allowed to cool, for which purpose it is turned out into boxes or upon hurdles, before proceeding to the operations of powdering and sifting.

3. Powdering and sifting expressed cacao.

This operation can be carried out in various ways. The melangeur represented at page 129 may be used, as well as the centrifugal sifting machine already described (see page 77). Among other machines applicable for the purpose, one specially constructed by J. H. Lehmann is represented by figure 67: it is on the principle of the edge runner mill with revolving bedstone and runners of granite. The coarsely broken press cakes are fed into the mill through a hopper fitted with a slide and are reduced to a loose powder of good colour, escape of dust being prevented by the hood fitted to the mill. By turning a crank, a lateral sliding door is opened, and an arrangement inside is set in motion, by which the ground cacao is turned out of the mill. The pressure of the runners can be regulated by a lifting arrangement and to any required extent.

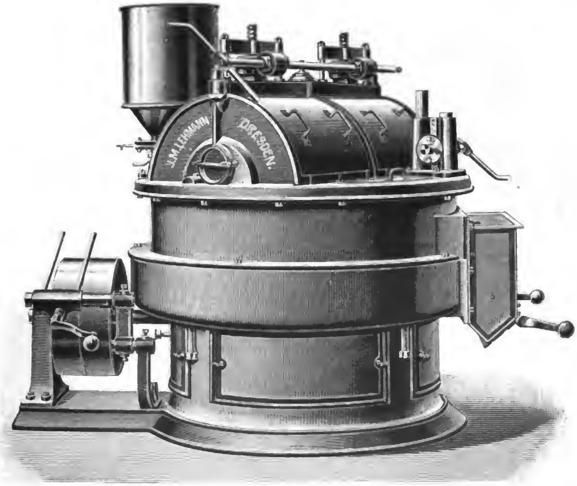

fig. 67.

The ground cacao after being cooled is passed on to the sifters, horizontal machines being used for that operation. Care must be taken not to attempt the sifting of large quantities of cacao with machines of inadequate size. Nor is an equally good result to be obtained by using any kind of sifting apparatus, unless it be specially adapted for sifting expressed cacao.

Lehmann also employs, for sifting cacao powder, a centrifugal sifting machine of modern construction as represented by figure 68. The cacao is fed in by an elevator; the sifting cylinder is covered with silk gauze and encloses a metal gauze sieve of coarse mesh, to hold back the larger fragments; inside that again there is a blower, by means of which the meshes of the sieves are kept clear, so that with proper attention no stoppage can take place and the outer surface of the sieve only requires to be cleaned twice in a day, an operation that takes only two minutes and can be carried out without removing the sieve. The ease with which this sifting machine can be cleaned gives it a marked advantage over all others.

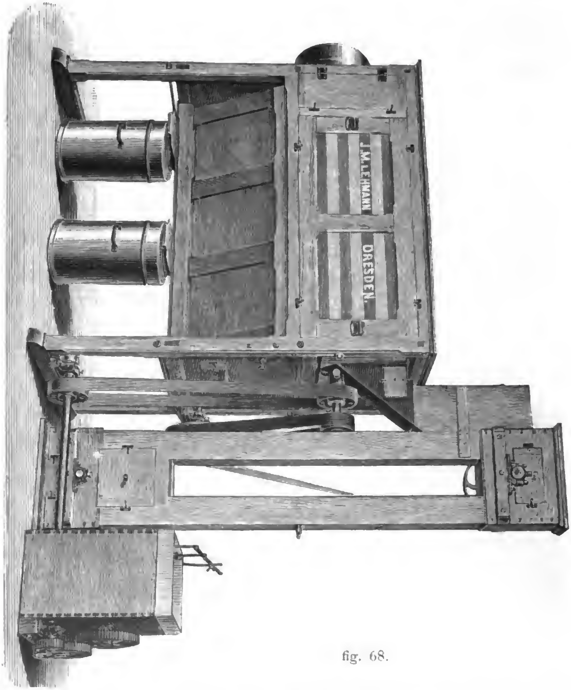

fig. 68.

The first delivery from this sifting machine consists of fine powder, while the second consists of the separated coarser particles that are to be again fed into the pulveriser. Both these machines may be arranged to work automatically, by means of elevators and worms for feeding and removing the material operated upon: in that way, considerable advantage can be secured. But pressed cake must first be crushed, before it is fed into the pulveriser through an elevator, and for that purpose the crusher represented by figure 69 is to be used. It consists essentially of a pair of toothed rollers which reduce the cake to fragments the size of a hazelnut. (See also no. 95 in figures 70a and b.)

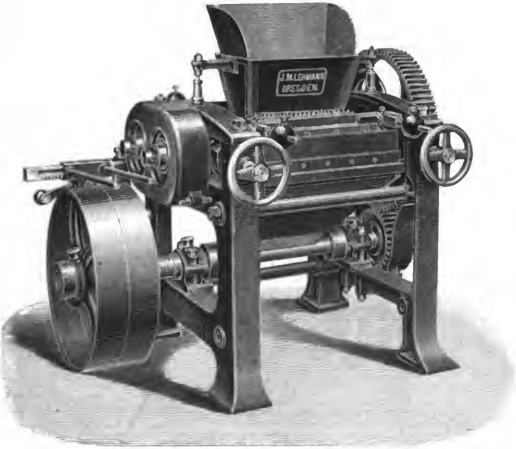

fig. 69.

The general arrangement of plant for automatic working according to Lehmann's system, is represented by figures 70a and b.

The press cakes are fed into the crusher 95 and the broken fragments are conveyed by the worm 5 to the elevator e which feeds the pulveriser 98, communication with it being regulated by the slide k. The delivery takes place on a raised floor P, where the ground cacao powder is allowed to cool. The worm S_2 then carries the powder to the elevator e_2 and to the sieve 93.

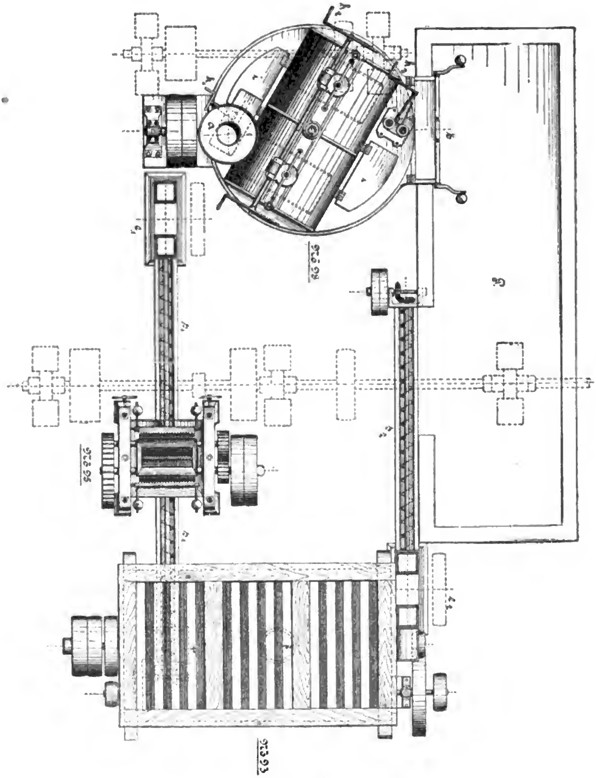

fig. 70a.

The receiver for the fine powder is placed at f and the siftings are carried from r by the worm s to 95, there mixed with fresh

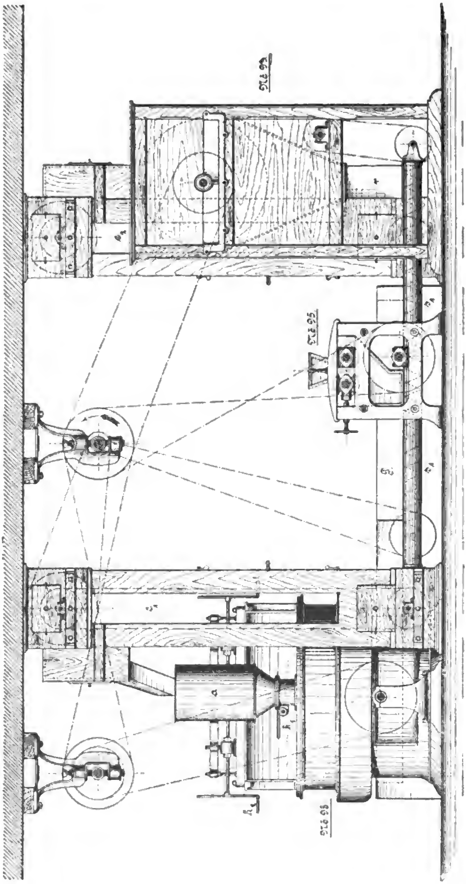

fig. 70b.

material and passed on to the pulveriser. A plant of that kind is capable of working from 750 to 1000 kilos of cacao powder daily; it requires about six horse power and only one attendant.

In connection with the Dutch method of preparing soluble cacao mention must be made of the process adopted by Moser & Co. in Stuttgart, in which the cleansed, shelled and moistened beans are subjected to the action of steam and ammonia vapour in a rotating drum, before they are roasted: ammonia is driven off in the roasting and the beans are then ground, the fat removed and the pressed cake finally powdered.

In addition to the Dutch method of rendering cacao soluble some other methods require to be mentioned.

4. Treatment after the roasting.

The chief difference between the Dutch method and the method now referred to consists in the treatment of the beans with alkalies after the roasting, while in the Dutch and some other methods, previously referred to, the treatment with alkali takes place before or during the roasting of the beans. The treatment with alkali may also be carried out before or after the expression of the fat. Accordingly, the several stages of treatment prior to the expression of the fat would be carried out in the latter case in the same order as in the manufacture of chocolate. But if the treatment with alkali is to take place before the fat is expressed, the cacao passes from the grinding mill direct to the apparatus where it is subjected to the action of a solution of potash, or whatever other alkali may be used.

a) Treatment before pressing.

The system, in which the ground beans, still containing fat, are impregnated with alkali, was introduced into Germany by Otto Rüger of Lockwitzgrund. His process does not require to be described in detail, since it is essentially the same as that adopted in the treatment of the liquid cacao mass with alkali. For that purpose the incorporating machine is generally used as described at page 129 and represented by figure 33.

The machines constructed, for kneading and mixing, by Werner and Pfleiderer of Cannstadt shown in fig. 71 a have been much in favour as preparatory machines. Fig. 71 b shows the machine with the kneading trough turned back for emptying. Mention may be made of the circumstance that in this machine the evaporation of the alkaline solvent is effected. The working of the kneading arms facilitates the escape of vapour from the mass and prevents over heating from contact with the sides. The trough is jacketed at the lower part and heated by steam.

To maintain connection of the steam and water pipes while the trough is reversed there are two flexible metal pipes. Both are screwed to the fixed pipes. For carrying away the vapour given off there is a tin plate cover to the trough provided with a charging aperture and a channel inside to catch the moisture collecting on the cover and discharge it outside. When the machine is to be emptied, the cover is raised up and a receiver adapted to the size and form of the machine is placed so that the charge can be turned into it. The tilting of the machine is effected mechanically by means of a lever and in order to prevent spirting of the liquid material, while discharging, the working of the stirring arms can be stopped meanwhile.

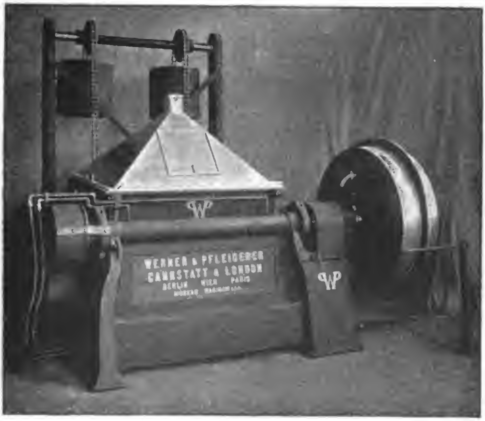

fig. 71a.

The solution of alkali is prepared in vats fitted with draw off cocks, or, in small factories, in glass carboys. Of the fixed alkalies, potash is preferable, since it is a natural constituent of the ash of terrestrial plants and therefore it does not introduce into the cacao any foreign ingredient. Magnesium carbonate appears to be used in some instances; but it is less suitable for the purpose since it is insoluble in water and, when suspended in that medium, is less readily incorporated with the cacao mass. Potash of from 90 to 95 percent may be used and it is soluble in an equal quantity of water. In preparing the solution, the best plan is to dissolve a known quantity in 3 to 4 times as much water at the normal temperature, and then to dilute that solution with sufficient water to bring it to the required percentage strength. For each 100 kilogrammes of cacao, containing fat, from 2 to 3 kilos of potash and from 15 to 20 kilos of water are required; 2 or 3 kilos of potash, should be dissolved in about 10 litres of water, and the solution then diluted with the remainder of the water. In using volatile alkali, ordinary ammonium carbonate in powder may be used, or ammonia solution. The salt is soluble in about five parts of water. For 100 kilos of cacao, from 0·5 to 3 kilos of ammonium carbonate

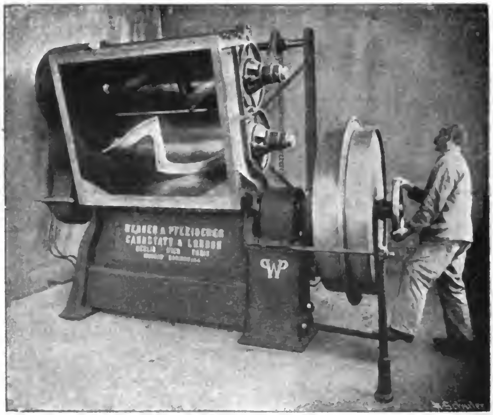

fig. 71b.

is generally required and it should be dissolved in 15 or 30 litres of water at once, for by using a smaller proportion of water, the salt decomposes and the acid carbonate, then formed, may remain undissolved. Ammonia solution acts more effectually than the carbonate and not more than one third as much will generally be sufficient. Consequently 100 kilos of de-fatted cacao should be mixed with 0·5 to 1 kilo of ammonia solution (Sp. Gr. 0·96) previously diluted with 20, or at the most, 29 kilos of water, The mixture should be prepared just before it is to be used, on account of the volatility of ammonia.

In this treatment of cacao, it is to be mixed with the alkali solution in the incorporator, or in the mixing and kneading machine (fig. 71a & b), steam being introduced, while the apparatus is working, in order to remove the water added, as well as the volatile alkali. From the consistency of the mass, the extent to which the water has been driven off may be judged of: the cacao mass must then be just as liquid, as when it came from the triturating mill. So long as the mass is a thick liquid, which sometimes happens when unsuitable mixing machines are used, there will still be some water left in it and that may lead to the growth of mould, or to the cacao having a grey colour when put up in boxes. In case the sufficient drying of the cacao cannot be effected in the mixing, the mass must be deprived of superfluous moisture in a suitable drying apparatus at a temperature of 48° C.

When volatile alkali is used, the kneading and mixing machine cannot well be dispensed with, because it allows of the cacao being more thoroughly worked and the ammonia better distributed through the mass than the incorporator will do. In that case, it is desirable to carry out the entire preparation in a space, separated from the rest of the factory, in order that the pungent smell of ammonia may not be communicated to other articles. At the same time, provision must be made for the escape of discharged gas through flues leading into the open air.

The treated cacao, when perfectly free from water and volatile alkali, then passes to the press and, in succession, to the pulveriser and the sifting machine, the several operations being carried out in the manner already described. According to the original method of O. Rüger, the treated cacao, after being deprived of fat, is broken up and the dried material is mixed with a certain proportion of fat, so that it is possible to prepare a "soluble" cacao containing the original amount of fat.

b) Treatment after pressing.

In this method, the mechanically prepared beans, that have been roasted, crushed and decorticated, are ground in the mill, then deprived of fat, the cakes broken into a coarse powder and treated with alkali as above described. Care must be taken, in that case, to use the least possible amount of water for dissolving the alkali. When working in this way, potash alone should be used since it has been found extremely difficult to drive off the last traces of ammonia from the cacao mass mixed with the solution, and there is no means of neutralizing the free ammonia, that can be employed, without at the sametime damaging the flavour and aroma of the cacao.

The strong solution of alkali may be conveniently added as a spray to the powder, while it is continuously being stirred, an operation which is best carried out in the incorporator. The final drying is to be effected in a hot closet which should be fitted for that purpose with an effective ventilator. After the drying is complete the cacao is passed on to the pulveriser and then to the sieve.

Some methods of rendering cacao "soluble" have now to be mentioned, according to which no alkali is used and the object in view is effected by means of water or steam. The first process of that kind was invented by Lobeck & Co. of Dresden in 1883.*) The cacao beans, either raw, roasted, decorticated, ground, or otherwise treated mechanically, are exposed to heat in a closed vessel and to the action of steam under high pressure, then they are dried and powdered. The use of steam for this purpose has little to recommend it. The effect is to render the starch soluble, also to establish acid fermentation which is detrimental to the finished product. Moreover, there is danger of the cacao treated in that way becoming mouldy, when stored.

Another process patented recently by Gädke**) consists in carrying out the treatment by exposing the moistened beans, after roasting and decorticating, to a temperature below 100° C. to dry them; they are then ground, the fat expressed and powdered, etc.

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*) German Patent No. 30,894 und Chemiker-Zeitung 1886, p. 1431.

**) German Patent No. 93,394, 17. January 1895.

According to the author's opinion, any one of the above mentioned methods, skilfully and carefully carried out, will give a marketable and wholesome product. That is especially true of the Dutch method, though it is open to the objection that it introduces into the cacao, so prepared, an extraneous substance which remains in the product and is consumed with it. From that point of view, the use of fixed alkalies, for rendering cacao soluble, is less desirable than the methods in which volatile alkali or water is employed for that purpose; moreover the author's investigation of the subject leads to the conclusion, that the treatment of powdered cacao, from which fat has been expressed, with volatile alkali is decidedly the best method of rendering cacao soluble. From a scientific point of view, that process must be regarded as the best one for the purpose, for on the one hand the disintegrated cacao, from which fat has been expressed, offers the most favorable conditions for the action of alkali, while on the other hand, the chemical agent employed can be separated from the product, except, in so far as it may enter into combination with constituents of the cacao. The chief difficulty experienced in the application of that method, is the complete removal of free ammonia from the cacao so treated. In that respect, the appliances hitherto available are open to improvement and the endeavour to provide means of effecting that object, may be described as one well worthy of attention from the machine industry that has already been so highly developed in connection with the manufacture of cacao products.

A well made soluble cacao powder should have a clear brown colour, without any tinge of grey; it should be perfectly dry and while finely divided should also feel light and soft. It should retain the peculiar aroma of cacao, without the least trace of ammoniacal smell. The taste should be agreeable like that of cacao, without any alkalinity indicative of defective treatment with alkali. Over and above the aroma and delicacy of taste, that character which is known to the public as "solubility", is a main criterion of the quality of cacao powder. To ascertain that, only an empirical test can be applied, by well mixing about 7,5 grammes of the powder with 150 grammes of warm milk or water in a graduated glass measure and observing how much sediment is deposited within a given time. The more slowly the sediment is formed and the smaller it is, the greater is the capability of the powder to dissolve, or more correctly speaking, to be suspended in the liquid medium it is mixed with.

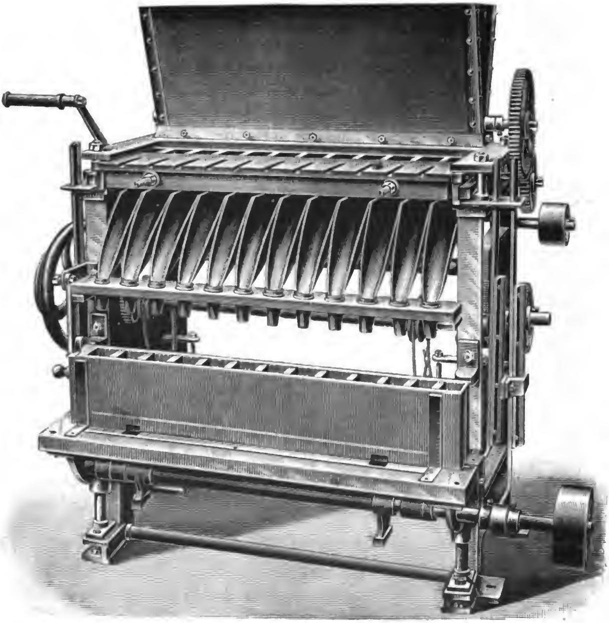

fig. 72.

If additional flavouring of cacao powder should be required, the same spices that are used in the chocolate manufacture may be added for that purpose, or the corresponding ethereal oils. Such additions are generally made in the course of the powdering operation and shortly before sifting.

For packing cacao powder in definite quantities, the Seelig apparatus by L. Wagner of Heilbronn on the Neckar, is used in large factories: it is capable of turning out from 8 to 10 thousand packets of equal weight in ten hours. The machine, represented by figure 72, works with a measuring arrangement and a shaking table upon which the packets are filled. It is driven by a pulley about 400 mm above the ground and for driving the shaking shafts the diameters of the pulleys are to be such that the upper shaft makes 230 revolutions, while the lower shaft makes 90 revolutions per minute. The driving pulley shaft can be drawn out; the bearings are best lubricated with paraffin-oil.

Before commencing work, the table carrying the box for holding cases, has to be adjusted against the shaft by which the shaking motion is caused. For that purpose one of the boxes, three or four of which are required for each size of packet, is charged with cases and placed on the table over the three stroke shaft. The small hand wheel is then turned towards the frame of the machine and the position of the table so adjusted, by turning the large hand-wheel, that the box with empty cases can be slipped on the table, without the openings of the cases being bent by contact with the hoppers. Then the position of the three stroke shaft is adjusted, so that the cogs run under the case box, without touching it and it is fixed by drawing back the small hand-wheel. If the case box is to be shaken during the filling of the cases, all that is requisite is to turn the large hand-wheel from right to left.

The adjustment of the measuring apparatus is effected by turning the crank working the tongues by which the measuring vessels are enlarged or contracted. The first packets filled are then weighed to ascertain that the adjustment is correct.

The manipulation is simple. The material to be packed is placed in the hoppers, the slides, bearing the measures, so adjusted by the hand-crank that the upper openings of the measures are under the hopper and the material may fall into them; then by slowly turning the hand crank the slides are moved forward and the measures are emptied out into the shaking channels which are kept continually in motion. The material is then conveyed into the cases which are kept in agitation by the three stroke shaft as long as may be necessary, for 20 to 30 seconds. The case boxes are then removed and the same operation repeated. While the cases are being taken out and replaced, the shaking motion is stopped by turning the large hand-wheel, and so raising the table.

For working the machine three boys or girls are required, one to work the hand-crank and the hand-wheel; two for removing and replacing the case boxes, taking out packets and putting in fresh cases. The cases are suitably made of good white paper, enveloped in an outer case of waxed paper or parchment paper.

The chemical composition of "soluble" cacao powder, has been the subject of numerous investigations, the most noticeable results of which require to be mentioned.

According to F. Elsner *) good soluble cacao prepared by the German method and with the fat expressed, has the following composition:

Water			5·00
Fat **)			27·50
Albuminous substances			20·00
Theobromine			1·50
Fibre			5·00
Starch			16·00
Other non nitrogenous substances			20·00
Ash	Containing:		5·00
	Potash	1·50	
	Phosphoric Acid	2·00	
			100·00

According to Stutzer ***) Cacao powder contains:

Water	from	5·00	to	6·00	per cent.
Solid material	,,	94·00	,,	94·5	,, ,,
Containing:					
Protein substances	,,	18·00	,,	19·00	,, ,,
Fat	,,	26·00	,,	31·00	,, ,,
Ash	,,	5·00	,,		,, ,,
Starch, Fibre etc.	,,	34·00	,,	40·00	,, ,,
Theobromine	,,	1·5	,,	2·00	,, ,,

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*) Die Praxis des Nahrungsmittel-Chemikers, 5th Ed. p. 326.

**) The amount of fat is now much less, since the expression has been carried so far as to leave only from 17 to 20 per cent.

***) See Forster, Hygienische Rundschau 1900, page 308.

Florence Yaple*) gives an idea of the composition of several kinds of cacao powder which are largely consumed.

Number	Name of trade samples	Moisture %	Ash %	Fat %	Extractive, soluble in water %	Theobromine %	Starch %	Albumin %
1	Rowntree's Elect Extract of Cocoa . .	4.05	7.70	30.82	7.48	1.08	—	15.22
2	Huyler's Caracas Cocoa	4.27	5.54	34.04	7.44	1.02	11.26	17.29
3	Breakfast Cocoa (Croft und Allen) . . .	3.98	4.24	32.48	6.52	0.56	17.65	17.27
4	Miller's Breakfast Cocoa	3.99	4.05	38.76	7.52	1.06	20.71	6.77
5	Fry's Cocoa Extract .	4.33	4.28	31.16	5.26	1.36	16.07	12.78
6	Walter Baker & Co. Breakfast Cocoa . .	4.44	5.23	27.52	6.62	1.28	23.34	15.74
7	Van Houtens Pure soluble Cocoa . . .	4.53	8.19	29.78	9.88	0.69	21.26	17.03
8	Bensdorp's Pure royal Dutch Cocoa . .	4.59	6.69	33.06	8.52	0.88	11.33	11.41
9	I. und C. Blookers Dutch Cocoa . .	4.64	6.70	31.78	7.70	1.22	15.90	16.87
10	Wilbur's Breakfast Cocoa	3.84	4.69	33.32	5.84	0.82	16.94	16.74
11	Cadbury's Cocoa Essence	4.00	4.70	27.58	6.48	0.70	21.05	13.58
12	Whitmann's pure Cocoa	2.70	4.15	37.68	4.10	0.66	16.26	14.13
	Average .	4.11	5.51	32.33	6.94	0.94	17.43	14.56

The amount of ash is a point of special importance in regard to the character and quality of cacao powder; also the amount of fibre for ascertaining adulteration with husk; naturally so, because preparation by the Dutch method has the effect of increasing the amount of ash, in consequence of the addition of potash, while adulteration with husk increases the amount of fibre.

The following analytical data given by Forster**) show the composition of the ash of cacao prepared by the Dutch method (Blooker's):

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*) Chemiker-Zeitung 1895. Repert No. 21, page 240.

**) See Forster, Hygienische Rundschau 1900 page 308.

	a %	b %	c %
Total Ash	6·31	6·55	7·82
Soluble in water	3·92	4·73	6·28
The ash contains: Potassium	1·94	2·31	3·15
„ „ Sodium	0·24	0·12	0·24
Phosphates	2·64	2·49	2·69

All kinds of Dutch cacao are distinguished by the large amounts of ash and potash. But Stutzer's statement,*) that treating cacao with potash or soda destroys the fine aroma, deteriorates the quality of cacao and renders it less digestible, is certainly an exaggeration, for most of the cacao powder manufactured by the Dutch method in Holland and elsewhere proves the contrary.

That remark however applies only to discreet addition of fixed alkali, for it is certain that an excessive quantity of alkali will entirely destroy the fine aroma of cacao, besides causing further alteration of the several constituents,**) Stutzer's opinion as to the hygienic disadvantage of the addition of alkali is also refuted by Forster's experiments, since the quantity of potash taken in a cup of cacao, made with 7·5 grammes of powder, is only 0·13 gramme, while the quantity taken in a cup of clear broth is 0·25, that in a glass of milk 0·31 gramme and that in 250 grammes of mashed potatoes 0·61 gramme.

In regard to the physiological assimilation of cacao rendered "soluble" by fixed alkali, Forster's experiments have shown that, in natural digestion in the human body, 90 percent of the dry substance is digested; of the nitrogenous substances 80 percent and of the fat and ash constituents 100 percent. According to those results, there can be no doubt as to the fitness of "soluble" cacao, prepared with fixed alkali as an article of food, especially since it is preferred by the greater part of the consumers. In the author's opinion such cacao is not open to objection, however it may have been manufactured, provided that, with a normal amount of alkali (2 to 3 percent), it has, in other respects a normal composition and satisfies the demands of consumers in regard to aroma and miscibility.

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*) Stutzer in Th. Weyl's Handbuch der Hygiene, Vol. III and Chem. Ztg. 1892. No. 65 page 1185.

**) Compare P. Soltsien, Chem. techn. Centralanzeiger 1885. No. 41 page 642.

One of the most objectionable forms of adulteration of cacao powder is the admixture of husk. The presence of husk is indicated partly by a slight increase in the amount of ash and of silica and partly by the increased amount of fibre (see pages 219 and 225). For the determination of the latter point, Filsinger's recent observations *) have furnished definite data. Operating with cacao powder, from which 20 percent of the fat has been extracted, he found:

Kind of cacao	Percentage of fibre
Puerto Cabello	6·71
Java	4·96
Ariba Guayaquil I	5·12
do. II	5·08
Machala-Guayaquil I	5·53
do. II	4·47
Pará	5·01
Surinam	3·76
Bahia	3·51
Granada	3·87
Guatemala	4·37
Caracas	4·56
Samana	5·72
St. Thomé A I	5·16
do. A II	3.68
do. B	3·93
Hayti	3·90

These data relate to cacao powder, from which 20 percent of fat has been expressed; but in case of further separation of fat, to the extent now generally practised, they will require corresponding modification. The analyst must therefore determine the amount of fat in any sample of cacao powder to be examined as well as the amount of moisture and then calculate the normal amount of fibre.

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*) Zeitschrift für öffentliche Chemie 1900, pages 223 and 417.

XI. Storing and packing cacao preparations.

Chocolate will keep for years, without alteration, when it is protected from the atmosphere. On that account, the general practice is to pack the preparations immediately after they are made, especially in the case of the better qualities, and in the case of ornamented articles, they are previously varnished over with an alcoholic solution of benzoin and shellac (see page 95).

Inferior goods are generally wrapped in paper and packed in wooden boxes, the better kinds are first wrapped in tin-foil and then in paper; cacao powder is generally packed in parchment paper cases enclosed in cardboard or metal boxes.

Modern trade competition has induced chocolate manufacturers to make the appearance of the wrappers more attractive. Among the several firms engaged in the production of wrappers and packages for cacao preparations special mention may be made of Etzold and Kiessling at Leitelsheim near Crimmitschau (Saxony), their products being distinguished by lightness and elegance as well as by the artistic taste displayed in their designs.

Although the packing of chocolate in waxed paper or parchment paper may be more wholesome and cheaper than wrapping in tin-foil, this latter plan has the advantage of preserving the aroma of spices mixed with the chocolate and also of preventing more effectually the rancidity resulting from long keeping. The tin-foil adheres firmly to the chocolate and thus hinders access of air.

According to the German law of 25. june 1897 (Reichsgesetzblatt No. 22), metal-foil containing more than one percent of lead must not be used for packing snuff or chewing tobacco or cheese. The same provision should apply in the case of cacao preparations which are in direct contact with the wrapping foil. Tinplate containing, in the tin coating, more than one percent of lead is also inapplicable for that purpose, and the solder used should not contain more than ten percent of lead. But it may happen, that the tin plate boxes sometimes fall short of that legal standard.

Manufacturers can protect themselves against prosecution for neglect of the requisite precautions in this respect only by obtaining a guarantee as to the quality of the tin-plate supplied to them.

The store rooms, in which chocolate articles are kept, should not be too warm, and they should especially be dry; heat causes volatilization of the aroma and facilitates the alteration by which cacao butter becomes rancid, while damp renders chocolate unsightly and promotes the growth of mould. After long keeping in damp dark warehouses, a development of mould always takes place, owing to the growth of a fungus which Royer has named "cacao-oidium".*)

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*) Beckurts Pharmaceut. Jahresbericht 1883—84, page 990..

XII. Arrangements for transport.

The transport of raw materials, as well as finished and partly finished goods, is effected in the factories by means of arrangements working horizontally and vertically. The former are in the form of trucks such as are represented in figures 17, 19, 21, etc.: in the larger factories, the trucks are conveniently worked on rails.

The arrangements working vertically are of three kinds:

1. Paternosters; elevators,
2. Hoisting machines,
3. Lifts.

The Paternoster consists of a strong belt or endless band working over two pulleys. Cups are attached to the belt, at regular distances apart, which hold the material to be carried. The whole is enclosed by a wooden casing. The supply is at the lower end of the construction. There the material to be transported is fed into the cups in which it is carried forward to the top and shot out, as the cups turn over, into tubes which deliver the material at the place where it is required. Contrivances of this kind are employed in connection with the machines for cleansing and picking the beans, also with those for crushing and cleansing, as well as with those for preparing the powdered cacao and for sifting.

The hoisting machines, an illustration of which is given in figure 50, serve chiefly for taking the moulded chocolate from the moulding room to the cellar or cooling chamber. The iron stages, passing up and down, receive the boards on which the moulds are laid out; this arrangement can be easily worked and stops automatically at its ends. J. H. Lehmann constructs lifts of the following dimension, which can be adapted to requirements of different factories:

Breadth 865 mm. Depth 700 mm. Height 900 mm.

The rolling chair-designs serve for carrying persons, as well as heavy packages (raw cacao, sugar, etc.) and they are now constructed in various ways. But they should be used exclusively either for persons or for goods. The German Otis-Company in Berlin supplies arrangements of this kind, capable of being worked by electric, hydraulic, pneumatic, or steam power as well as by hand. They should always be constructed so as to guard against accident.*)

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*) See: Die Chemische Industrie 1897 No. 14, page 310.

XIII. The motors.

To obtain the power required for driving the machines employed in the manufacture of cacao various motors have come into use.

The cheapest motive power is obtained by the use of water and it can be shown that water power arrangements work better than steam engines, although they require a larger outlay of capital in the outset. Generally speaking, in a plant worked by steam, horse power costs at the rate of from 200 to 300 marks*) for construction. The working expenses per horse power, for 24 hours work, amount to from 250 to 270 marks a year. In a water power plant the original cost of construction certainly amounts to as much as 600 or 800 marks per horse power, but the working expenses for the first year, allowing for writing off the cost of construction, do not amount to more than 160 or 200 marks per horse power, and after the cost of construction is completely written off, it does not amount to more than from 20 to 30 marks per horse power.

But since water power is rarely available, the manufacturer must make use of steam power, or gas, petroleum, or electro-motors.

On the large scale, the steam engine is of most importance for cacao manufacture, more especially since large quantities of steam are required for heating the various machines employed for different purposes.

In operations on a small scale, requiring only some five horse power, or less, one or other of the different forms of small motors can be used, the cost of which per horse power is according to Berndt**) as follows, after taking into account interest, writing off, lubrication, and cost of maintenance.

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*) 1 Mark (= 100 Pfg.) = 1 shilling or 1 quarter-dollar.

**) Mittheilungen a. d. Praxis des Dampfkessel Dampfmaschinen-Betriebes Berlin-Breslau 1900 XXII No. 9 page 222.

Gasmotor	1500 working hours a year	23·2	Pfg.
Petroleummotor . .		34·5	„
Electromotor. . . .		24·0	„
Benzin-(Naphta)motor		28·8	„
Hot airmotor . . .		0—23·5	„

For these figures the cost of coal is taken as 1·96 pfg. per kilo, gas at 12 pfg. per cubic metre, petroleum at 23·5 pfg. per kilo, benzin at 26·5 pfg. per kilo, and the kilowatt hour at 200 pfg. (with 10% allowance).

The one horse power steam engine would, under the same conditions, cost 22·9 pfg. per hour, calculating allowance for installation, interest and repairs at 15 percent and 25 pfg. for 100 kilos of steam.

On the basis of the foregoing data and according to other conditions, the selection of a suitable motor for operations on a small scale should not be difficult.

As already mentioned, the steam engine is best adapted for large works, although the effective utilization of heat in the best steam engine, even on the large scale, does not amount to more than 12—15 percent of the quantity of heat generated by the fuel used. Recently, petroleum motors have come into use and they successfully compete with steam engines. Among these, the Dieselmotor is especially deserving of mention, for by means of it the effective utilization of heat amounts to 25 percent or about 11 percent more than can be effected with the steam engine.

The Dieselmotor does not act, as in the ordinary explosion machines, by ignition of a compressed mixture of atmospheric air and combustible; but atmospheric air is first highly compressed, and the combustible then injected into it. The temperature of ignition is in this case produced by the compression, so that the injected combustible at once takes fire.

The Dieselmotor appears to be superior to others mótórs, and in illustration of this, the following tabular comparison is taken from A. Musil's work on heat motors 1899. It shows the consumption for effective hour horse power, under normal conditions of working (10 hours work for 300 days in the year) taking the unit cost of fuel.

Working cost of effective hour horse power:

Motors	Unit cost	20 HP.	50 HP.	90 HP.
Gasmotor (Illuminating gas)	1 cb metre Gas . 10 Pfg.	7·9 Pfg.	7·2 Pfg.	6·8 Pfg.
Gasmotor	„ „ . 15 „	10·7 „	9·8 „	9·3 „
Dieselmotor . . .	1 kg Petroleum . 17 „	7·3 „	6·9 „	6·5 „
„	1 „ „ . 22 „	8·5 „	8·0 „	7·7 „
„	1 „ solar oil . . 13 „	6·4 „	6·2 „	5·9 „
Gas (power) motor .	100 kg Anthracite 2.80 M.	7·4 „	5·2 „	4·1 „
Steam engine . .	100 „ Coal . . 2.20 „	11·2 „	7·0 „	5·0 „

The use of Dowsongas is also very advantageous and economical for working gas motors.*) Since Dowsongas is also very applicable for heating purposes it serves as an excellent source of heat for working the roasting apparatus.

In large towns and places, where land is dear, the gasmotors or the Dieselmotor would have an advantage over the steam engine, because they can be fixed in a cellar, while the steam engine requires that the boiler house, at least, shall be so situated that it is apart from dwellings or buildings used for other purposes. Then since the use of steam pipes, for warming, has to be carried out on a large scale in the cacao manufacture, it would be advisable in some instances to divide the work between steam motors and gas or Dieselmotors, in such a manner that the latter are employed for purposes requiring much power, while steam engines are employed for those purposes, where heating is requisite. By using gasmotors, the whole of the power needed could be supplied by them, while for heating purposes, a steam boiler, fitted with valves to reduce pressure to 2 atmospheres, would supply all the requirements of heating. Those machines which require most power for working, such as the incorporators, also require the greatest application of heat. In every part of the chocolate manufacture heat is necessary, more or less, so that the length of the steam pipes is not of much account, provided the arrangement of the factory is otherwise convenient.

In using steam engines, the steam required for heating the machines should be supplied direct from the boiler, under reduced pressure, and the use of exhaust steam should be avoided

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*) Compare: Boeking Zeitschr. d. Ver. Deutsch. Ingenieure 1887, page 1007) and W. Schmidt ibidem page 1009.

(except for warming the works or drying closets) since that would increase the pressure on the cylinder, so that frequently the use of exhaust steam, though it costs nothing, involves a much greater cost in steam for working the engine than would attend the direct use of steam for heating. Moreover in the larger steam engines, which are provided with condensers, there is no exhaust steam.

Recently, the use of electromotors has been very largely introduced into chocolate works; they are to be recòmmended wherever a supply of current is to be obtained cheaply as in the immediate vicinity of large rivers or waterfalls the motive power of which can be applied for the purpose; also in large towns where there are electrical stations and land as well as hand labour are costly. Electromotors do not occupy much space; the consumption of oil and the cost of attendance are reduced to a minimum, moreover the possible application of electricity for lighting, as well as power, would be a further advantage and detached portions of the works could be easily supplied, for both purposes, by connecting wires.

The application of electromotors is not confined to places where a cheap supply can be obtained, but it is gradually increasing where a supply has to be provided specially; partly for the reason that it admits of the steam engine being fixed without regard to the situation of the working rooms and partly because the details of the manufacture can be more conveniently grouped, each with its own motor, as for example:

a) Cleansing, roasting and crushing,
b) grinding mills and hydraulic presses,
c) incorporators,
d) rolling mills,
e) shaking tables,
f) pulverisors and sifting apparatus.

According to the extent of the works, the groups may be more or less numerous. By means of such grouping, the necessity of shifting material from one part of the works to another may be avoided to a great extent, as well as the consequent waste of power. The cost of installation of an electrical plant, of the kind referred to, would naturally be much higher than when the work is carried on by means of gas or steam, although the working expenses might be reduced, as a result of more convenient arrangement of the several departments. Such a mode of working has moreover the advantage of allowing certain details of the manufacture to be carried out independently. Greater security of continuous working would also result, since the entire operations would be liable to stoppage from the breaking of a main shaft, etc., and the possibility of being able to stop only one part of the works, in case of an accident, is not to be underrated. In textile manufactories or printing works, the several machines are directly connected with the motors and, consequently, there is no need of driving belts. Machines of that kind ensure a well defined amount of power. But the machines used in chocolate factories require, independently of the attendance and mode of operating, an intermittent exercise of power, so that very powerful motors would be needed for driving the several machines in order to work continuously. For that reason, the cost of installation would be very considerable. Moreover, the working parts of almost all the machines used in chocolate making, have a very low velocity and that would necessitate provision for regulating the velocity (especially in the case of small motors) with consequent waste of power. For that reason, the system of working in groups, with a motor in each one, is in every respect most desirable.

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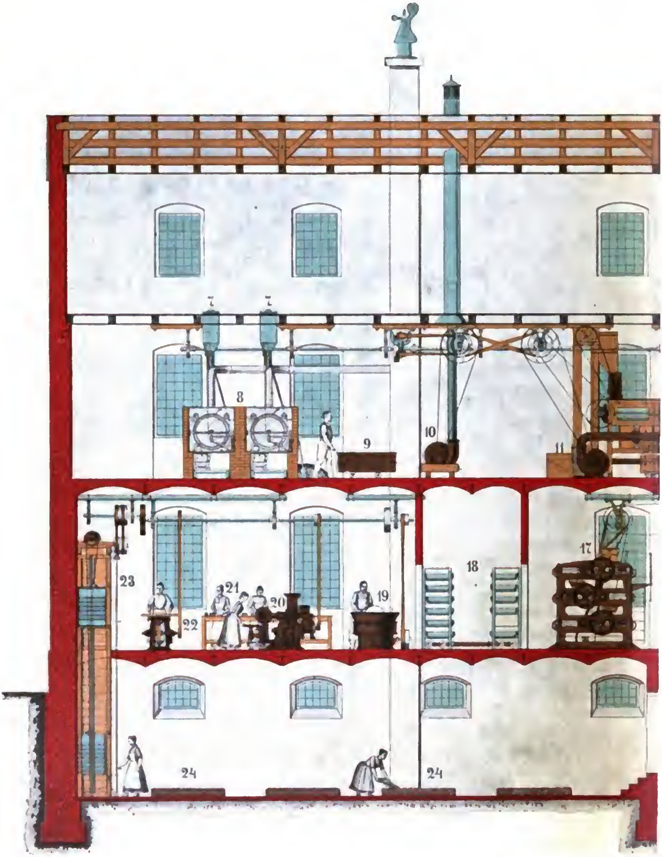
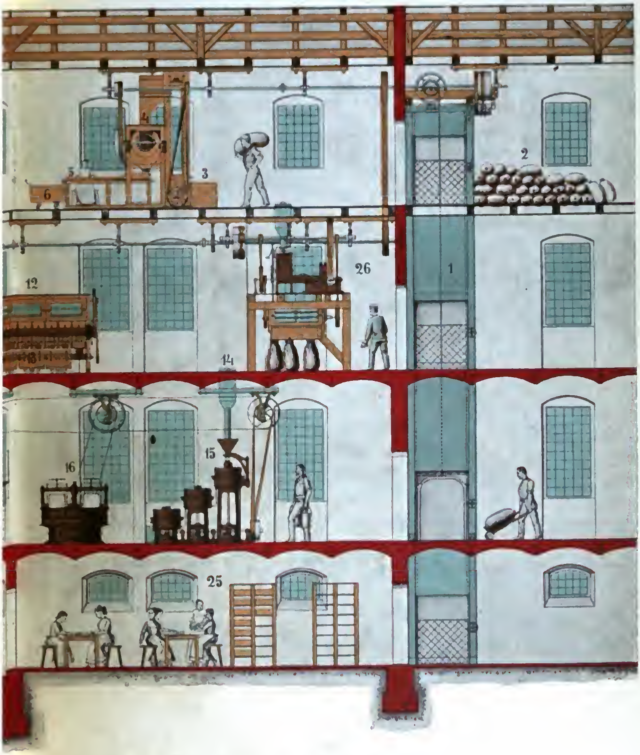


Originalentwurf der Maschinenfabrik .

l chocolate factory.

itt einer Chocoladenfabrik.

See page 215 and 216.



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XIV. Installation of a chocolate and cacao powder factory.

In constructing a new factory and fixing the situation of the buildings, the first thing to be considered is their convenient arrangement. It is therefore advisable to rely upon an experienced person for the plan to be adopted, and then to leave the proper construction of the works in the hands of the architect. Small operations can be carried on in any building, but in the case of larger works a well devised arrangement of the machines and appliances must be decided upon before hand, that will admit of rational and, to some extent, automatic working. In case of erecting small works which will require only one manager, the best plan would be to have the whole manufacture carried out on one story, or at the most two stories, for the sake of more easy oversight.

The case is different with large works, in which the different departments are controlled by especially qualified persons.

Tables I and II*) represent, in section, a chocolate factory and a cacao powder factory. Both plans have been designed by the firm J. H. Lehmann of Dresden, by whom they have been obligingly placed at the author's disposal. As both plans represent only a model section, they serve only to show the most convenient arrangement of the machines with each other. In reality there would be more or less machines of the same kind placed together. Such arrangements might, with more or less modifications, serve for medium sized works, as well as for larger ones. In that sense the following explanations of the two plans are to be understood.

1. Chocolate factory (Table I*).

By means of the lift (1) all the raw materials, sugar, cacao, packing materials, etc. are carried up to the store rooms (2). In that upper space are the machines for cleansing and picking the raw cacao beans. The raw cacao is fed into the elevator boxes (3), above the cleansing machine (4) where it is freed from dust; it passes to the continuous band (5) where it is picked and then falls into the movable boxes (6). It is then transferred to the hoppers (7) and is fed, by opening a slide in the hoppers, into the roasting machine (8). The capacity of the hoppers is sufficiently large for holding the quantity of beans for charging the roasting machine. After the roasting is completed, the cacao is emptied into the trucks (9) and carried to the exhaust arrangement (10) where the beans are cooled down and the vapour given off is passed out into the open air. At the same time, the roasting chamber is sucked out through the funnel shaped tube fitted to the cover of the chamber. The roasted cacao is then passed to the boxes (11) to be conveyed by the elevator to the crushing and cleansing machine (12). After being cleansed, the cacao is carried in trucks (13) to the hoppers (14) by which they are fed into the mills (15) in the lower floor. The sugar mill and the sifting apparatus (26) placed near the crushing and cleansing machines are also fed by a hopper from above. The dust sugar, there produced, is carried by the lift (1) to the machine room on the first floor. Cacao and sugar are there supplied to the incorporator (16) to be worked together, before being passed to the rolling mill (17), where the final rubbing is effected. After passing once or oftener through the mill, the finished chocolate mass is then taken to the hot room (18) where it remains in boxes until further treated and it is then taken to the moulding room. In the incorporator (19) the mass acquires the consistence necessary for moulding and also the requisite temperature. The mass is then taken in lumps to the dividing machine (20) and cut into pieces of the desired size and weight. On the table (21) the moulds, lying upon boards, are filled with the pieces of chocolate and they are then taken to the shaking table (22). By means of the double lift (23) the moulded chocolate, lying upon boards, is conveyed to the cooling room or cellar, in which there are benches (24) or frames for receiving the moulds, that are slipped off the boards. According to situation, the cellar has to be cooled artificially. Adjoining the cellar is the wrapping room (25) and further on, the warehouse. The goods so far finished are then taken by the lift (1) to the rooms where they are packed for delivery.

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*) See: Appendix.

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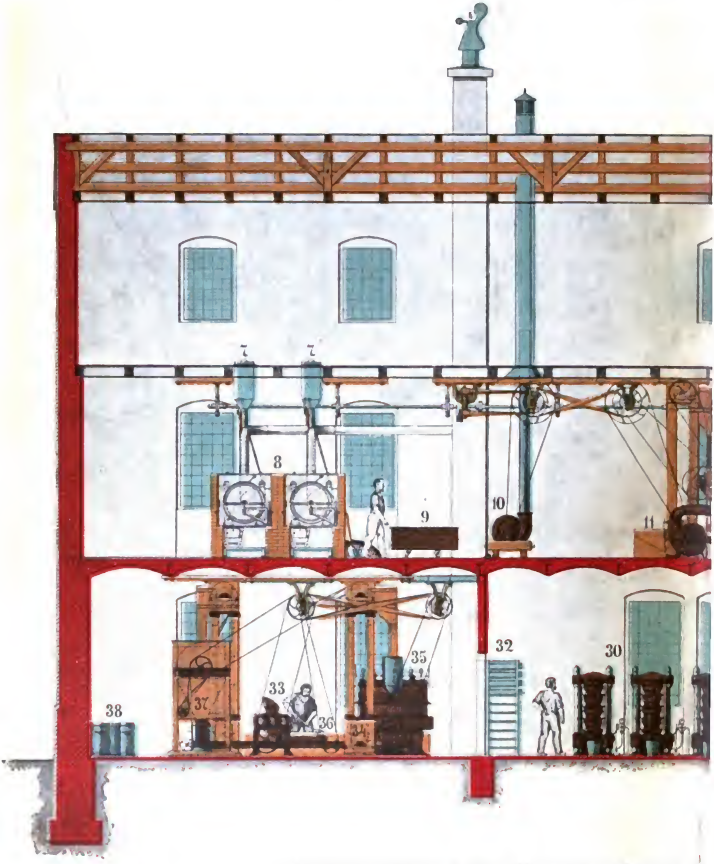
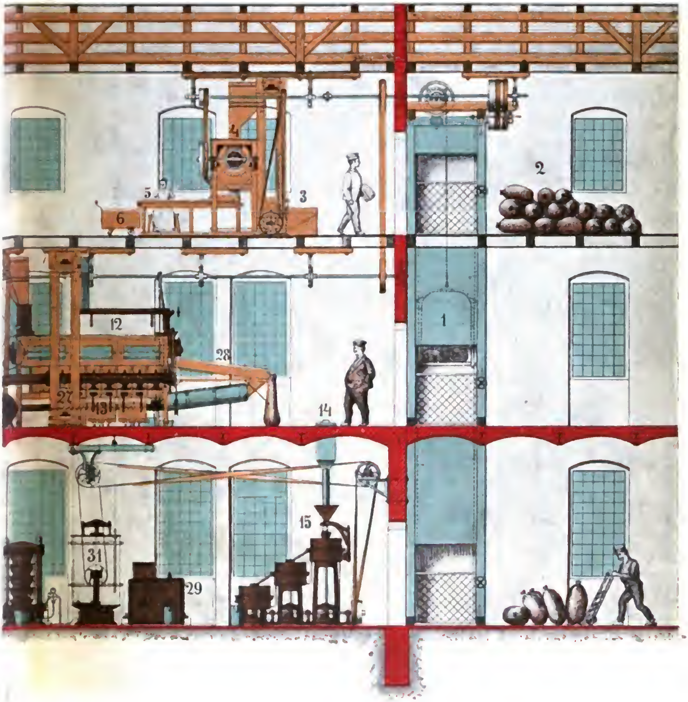


Originalentwurf der Maschinenfabrik J.

del cacao factory.

chnitt einer Cacaofabrik.

See page 217.



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2. **Cacao powder factory** (Table II*).

The course of manufacture of cacao powder is the same as in the manufacture of chocolate, up to the point where the cacao has passed through the crushing and cleansing machines (12). The broken beans are then taken by the elevator (27) to the machine for separating the radicles (28) and thence through the hopper (14) to the mills (15). The liquid cacao mass, passing from these mills, runs into the pans (29) from which it can be drawn by cocks as required for charging the hydraulic presses. The accumulator (31) supplies all the presses with water. The pressed cakes are first put into the boxes of the frame (32). In an adjoining room is the automatic cacao pulverizing apparatus. It is fed through the preliminary crusher (33) from which the cacao is taken by the worm and elevator (34) to the pulverisor (35). The powdered cacao is then taken by a worm and elevator to the sifting machine (37).

The sifted powder falls into the tub (38) while the coarser portion is carried back again to the pulverisor (35). The arrangements for treating the cacao powder and rendering "soluble", can be provided in the manner already described at page 197.

In both plans, the boiler and engine house are to be understood as placed in an adjoining building.

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*) See: Appendix.

XV. The chemical and microscopical investigation of cacao preparations.

The following matter is introduced for the food chemist and to serve, as much as possible, as an introduction to the chemical and microscopical investigation of cacao preparations. The author is in the fortunate position of being able to utilize, to some extent, an unpublished work by Filsinger, produced at the request of the Society of German Chocolate Manufacturers, as an appendix to the last volume of the „Vereinbarungen zur einheitlichen Untersuchung und Beurteilung von Nahrungs- und Genussmitteln sowie Gebrauchsgegenständen für das Deutsche Reich", published by the Kaiserlichen Gesundheitsamt. At the same time, various other tried methods of investigation will be given, but in order to avoid repetition those already described will only be referred to.

1. Chemical investigation.

The chemical investigation of cacao preparations chiefly comprises the determination of moisture, mineral constituents (quantitative determination of alkaline carbonates and silica) — fat (detection of foreign fat) — theobromine and caffeine — sugar — starch (foreign starch), albuminoids and fibre; the last serving for the determination of the amount of husk.

a) Determination of moisture: 5 grammes of the substance (chocolate in fine shavings) are dried in a jacketed drying oven, filled with glycerine, for about 6 hours at 105° C., and the loss in weight is calculated as water. The operation should not be continued longer than 6 hours as the weight then increases through the absorption of oxygen by the fat. In operating with chocolate, the mass should not be allowed to cohere; but should that occur, the following method should be carried out: about 10 grammes of sand in fine grains are placed in a flat watch glass, then dried, cooled and weighed; 5 grammes of finely shaved chocolate are added; the mixture dried for 6 hours at 105° C. and allowance made, in the calculation, for the sand added.

Chocolate with an admixture of only 5 percent of gelatine may contain 10 percent of water without any alteration in appearance, although the taste is essentially affected. A high percentage of water may therefore indicate the addition of gelatine. For the detection of gelatine, P. Onfroy *) takes 5 grammes of the rasped chocolate and boils with 50 ccm of water, then adds 5 ccm of a 10 percent solution of lead acetate and filters the liquid. On the addition of a few drops of a saturated solution of picric acid to the filtrate a yellow amorphous precipitate shows the presence of gelatine. If the amount of gelatine is very small, it will be retained by the cacao-red. In that case, the chocolate, de-fatted by means of ether, is levigated with 100 ccm of hot water, then mixed with 5—10 ccm of 10 percent solution of caustic potash and 10 ccm of the 10 percent lead acetate solution; the compound of gelatine and cacao-tannic acid (cacao-red) is dissolved by the potash, and is not precipitated by the lead acetate and it can be detected in the neutralised filtrate by picric acid. As theobromine is not precipitated by picric acid, the precipitate can only be due to gelatine.

Tragacanth serves the same purpose as gelatine, to introduce water and to save the fat. For the qualitative demonstration of tragacanth, which may amount to 2 percent, a method has lately been given by Welmans, which will be described in the microscopic section.

b) Determination of Ash: 5 grammes of the substance are heated in a platinum crucible of 25—30 ccm capacity, taking the precaution, that the tip of the Bunsen flame only touches the bottom. The disengaged gases are ignited and, after complete coaling, the mass is pressed together with a platinum wire or rod and then the crucible, being placed obliquely, is heated, while the contents are stirred up, with a fairly large flame until the ash becomes almost white. When that point is reached the crucible is allowed to cool, the ash saturated with a concentrated solution of ammonium carbonate, then placed in the drying oven and dried at 100° C. After a very careful heating over the Bunsen burner — the bottom of the crucible must only for a short time reach a red heat — the covered crucible is allowed to cool in the desiccator and then weighed. The operations of moistening with solution of ammonium carbonate, drying and gentle heating, are repeated until the weight is constant.

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*) Journal de Pharmacie et de Chimie 1898. Vol. II, p. 7.

c) Determination of silicic acid in the ash: The quantitative determination of silicic acid in the ash is sometimes necessary in the testing of cacao powder and chocolate, since it may give evidence as to admixture of husk. The ash of the cacao beans contains only 0,25 percent of silicic acid, while the ash of the husk contains up to 9 percent; at the same time, it must be taken into consideration, that a large amount of silicic acid in cacao powder may also be due to the use of impure potash. The determination of silicic acid is made on a large quantity of the ash (4—5 grammes), according to the method of analysis described by C. R. Fresenius (Quantitative Analysis 6. German edition, II. volume, page 644), and as certain kinds of cacao powder (Dutch), contain a considerable amount of carbonates the precautions, indicated in that case, must be observed.

d) Determination of the added alkali (in cacao powder): The ash obtained from 5 grammes of cacao powder is washed from the platinum crucible with distilled water into a beaker, broken up with a glass rod and heated to boiling, allowed to settle, filtered and well washed; 5 c. c. of $\frac{n}{1}$ sulphuric acid are then added, the solution heated to boiling and titrated back with $\frac{n}{2}$ or $\frac{n}{4}$ caustic potash.

In this way is obtained, the amount of added alkaline carbonate and that which has been produced from the organic salts, normally present in cacao by ignition. Welmans*) has determined the amount of alkali in the ordinary kinds of cacao beans and has placed at the author's disposal the results obtained. They are as follow:

a) Unshelled, roasted beans.

Per cent	Ariba I	Ariba II	Caracas I	Caracas II	Guajaquil	Trinidad	St. Thomé
Ash	4·198	4·02	7·52	4·376	5·12	3·6	3·92
Soluble in water .	1·698	1·66	1·34	1·676	2·11	1·565	1·604
Insoluble in water	2·5	2·36	6·18	2·70	3·01	2·035	2·32
Alkali (calculated as potash) . . .	0·6417	0·6417	0·596	0·9936	0·84	1·125	0·67

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*) Privately communicated.

b) Shelled, roasted beans:

Per cent	Puerto Cabello	Ariba I	Ariba II	Caracas I	Caracas II	Guaja-quil	Trinidad	St. Thomé
Ash	3·62	3·701	3·49	3·845	3·62	3·926	3·277	3·27
Soluble in water . .	1·72	1·423	1·315	1·76	1·62	1·476	1·727	1·34
Insoluble in water . .	1·90	2·273	2·175	2·08	2·00	2·45	1·55	1·93
Alkali (Potash) . . .	0·603	0·323	0·388	0·8725	0·4478	0·402	0·4209	0·4048
Alkali in powdered cacao with $33^{1}/_{3}$ per cent af fat calculated	0·808	0·436	0·52	1·169	0·600	0·54	0·594	0·542
Ash, calculated as above	4·822	4·959	4·676	5·152	4·85	5·26	4·39	4·38

These tables show that:

1. The ash of cacao powder (containing $33^{1}/_{3}$ percent of fat) is never more than 5·5 percent.

2. The maximum amount of alkali (calculated as potash) is 1,2 percent.

3. The ash soluble in water is always less than that insoluble in water. A reverse proportion shows a larger amount of alkali that is, alkali has been added.

In addition to the importance of determining the amount of alkali in powdered cacao, it is very desirable that analytical chemists should agree as to the methods to be adopted, since the determinations of alkali seldom agree and may differ as much as 0,30 percent. The method of calculating the results should also be defined, that is to say, an agreement should be arrived at as to whether the alkali should by expressed as KHO, K_2O, K_2CO_3 or Na_2 CO_3.

Cacao which has been rendered miscible by means of ammonia, sometimes contains a small amount of ammonia, probably in combination with an organic acid. To detect it, the cacao powder should be distilled with water, which gives an alkaline distillate, as the ammonia salt would be decomposed at the temperature of boiling water. The ammonia can be volumetrically determined in the distillate with sulphuric acid.

e) Determination of fat: This is carried out by the processes described on page 36 and 38.

Welmans*) has further described a quick and practical method for determining fat in cacao and its preparations, which is not only of value as a control of the extraction method, but also serves as a determination of the constituents soluble in water. It is carried out as follows:

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*) Zeitschrift für öffentliche Chemie 1900, page 304.

5 grammes of cacao powder or cacao mass, which need not be very fine, or 5—10 grammes of chocolate are agitated for some minutes in a separator or cylinder with 100 ccm of ether (saturated with water) until coherent particles are no more visible, that is to say, until the factory degree of fineness has been attained. In two minutes all will have gone to powder even if the chocolate has not been rubbed down but is in pieces; 100 ccm of water (saturated with ether) are then added, and the mixture agitated until a complete emulsion takes places. With powdered cacao, especially those kinds rich in fat, that occurs in ½ to 1 minute, and with chocolate in 2 minutes. It is then allowed to rest until the emulsion separates, which at the ordinary temperature of 15—20° C. usually occurs in 6—12 hours in the case of chocolate, and 12—24 hours with cacao. The greater part of the water separates first and, usually, amounts to 90—98 ccm with chocolate and 70—86 ccm with cacao. The powdery portion of the cacao or chocolate floats on the surface of the aqueous layer at the bottom of the ether layer. Only husk, sand, particles of cacao beans, added starch, etc. accumulate at the bottom of the separator and are to be removed with the aqueous layer, which in the case of chocolate contains the sugar, but usually no trace of fat. The ether layer, which freely separates from the emulsion in the time mentioned, is quite clear and from 25 to 50 ccm can generally be pipetted off and an aliquot part poured into a measuring cylinder or graduated tube, or into a 25 or 50 ccm flask. If the ether solution of fat is not sufficient in quantity, the separation can be effected after removing the aqueous liquid by twirling round the separator. The turbidity soon disappears and the non-fatty particles quickly sink to the bottom. The ether solution of fat can also be examined aräometrically, as with milk fat, by Soxhlet's aräometric method, after forcing it by means of an india rubber ball, into a pipette or burette, but the constants to be used in that case have not been ascertained. After the ether has been distilled off, in the normal manner, the weight obtained must be calculated for 100 ccm and a small correction made. For example, if 50 ccm of the ether solution of fat give a residue of 0·8 gramme, then 100 ccm = 1·6 gramme. But this 1·6 gramme has not

been obtained from 100 ccm of the original (water saturated) ether, but from 100 — x ccm. X representing the number of cubic centimetres corresponding to 1·6 gramme of cacao butter and, as the specific gravity of cacao butter is nearly = 1; the equation becomes $(100-1{\cdot}6) : 100 = 1{\cdot}6 : x$: $x = \frac{160}{98{\cdot}4} = 1{\cdot}627$ gramme; so that the 5 grammes of substance would contain 1·627 gramme fat or 32·54 percent.

The remaining aqueous solution will contain the soluble constituents of the cacao or chocolate. It is poured into a graduated cylinder and measured, and, if the whole is taken to dryness, the residue is calculated for 100 parts. But the following method is better: 10 ccm of the liquid are evaporated, the residue well dried in a vacuum and then weighed; the result obtained, multiplied by 10, gives the amount of constituents soluble in water from 5 grammes of cacao or 10 grammes of chocolate. Sugar can be determined in the aqueous extract in the following manner: 50 ccm are warmed in the water bath until free from ether, then made up to 50 or 55 ccm with basic lead acetate solution and polarised in the usual way. If the polarisation shows more sugar than the weight of the total residue then dextrin is present as an adulteration.

The quantitative determination of dextrin, which is sometimes added to powdered cacao, as well as to chocolate, as like gelatin and tragacanth it holds water and ensures a saving of fat, is best carried out by the method (polarisation) of P. Welmans.*)

As the amount of fat obtained from 5 grammes of a cacao preparation does not suffice for testing for purity a larger quantity must be extracted in order to carry out the following quantitative investigation:

1. Determination of melting point,
2. „ „ Iodine value,
3. „ „ saponification value,
4. „ „ acid value,
5. „ „ Reichert-Meissl value,
6. „ „ refractive power in Zeiss's butter refractometer.

For an exact description of the tests and manipulations, the frequently quoted work of R. Benedikt: „Die Analyse der

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*) Zeitschrift für öffentliche Chemie 1900, page 481.

Fette und Wachsarten, V. erweiterte und nach dem Tode des Verfassers von F. Ulzer herausgegebene Auflage, Berlin, Verlag von J. Springer 1897." should be consulted.

Should a doubt occur as to the result of these six tests which may happen with some kinds of commercial cacao butter, it is recommended to employ the empirical ether test of Björklund or Filsinger's alcohol-ether test about which every point of importance has been stated at pages 39 and 40.

f) Determination of theobromine and caffeine. Eminger's method is the only one at present worth consideration and it has been described at page 51. In the practical investigation of cacao preparations, the separation of the two diureides is of no importance, and the total amount of the diureides need only be ascertained. In the author's opinion, determination of the diureides is of little value, as it gives no indication of the quality of the goods.

g) Determination of starch. This can only be of importance in rare instances, as the starch naturally present in raw cacao generally varies between 9—15 percent, and there is no chemical method for separating foreign starch from cacao starch. But should a determination be necessary, it should be conducted according to the directions at page 60. If Welmans agitation method has been used for determining the fat (see page 222) the starch will be found in the sediment. The amount of foreign starch can be ascertained by the microscope (see page 230) as well as by Posetto's*) method, which depends on the intensity and permanency of the iodine reaction. In the latter test, 2 grammes of the powdered or finely shaved cacao preparation are boiled with 20 ccm of water in a test tube for 2 minutes, it is then cooled, and without disturbing the liquid, 20 ccm of water and 5 ccm of iodine solution (5 grammes of iodine and 10 grammes potassium iodide in 100 ccm water) are added. The liquid from genuine cacao, according to the kind used, becomes brownish to light blue and even blue, changing in a short time (maximum in 12 minutes) to brown and red. On the other hand, chocolate or a cacao preparation mixed with no more than 10 percent of wheaten or potato starch, chestnut or maize, or commercial dextrin will give a blue colouration lasting for 24 hours. It must be noted, that in Posetto's test, the result is influenced by the amount of alkali, so that with soluble cacao for example, a considerable quantity of iodine has to be added before the blue colouration of the starch takes place and that is especially the case if the potassium carbonate employed contained caustic alkali. Such preparations finally become coloured but generally have a mixed colour (blue and yellow): green to greenish brown.

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*) Giornale di Farmacia, di Chimica etc. 1898. Gennaio.

h) Determination of fibre. This can be carried out in two ways. Either by König's new process as employed by Filsinger for cacao (compare page 62), or by the older method of Weender's as follows: 3 grammes of the de-fatted and air dried substance are boiled for ½ hour with 200 ccm of a 1,24 percent solution of sulphuric acid. It is allowed to settle, then decanted and the residue boiled twice with the same volume of water. The decanted liquids are allowed to settle and the sediment added to the rest of the substance, which is then boiled with 200 ccm of a 1,25 percent solution of caustic potash, filtered through a weighed filter and the residue twice boiled with 200 ccm of water. The cellulose like substance on the filter is washed with hot water, then with cold water, afterwards with alcohol and finally with ether. After being dried and weighed, it is incinerated and the necessary correction made for ash.

i) The determination of cacao husk, which will be for the most part a matter of ascertaining the amount of fibre, could until two years ago only be effected by means of the microscope. Recently Filsinger[*]) has proposed a method of levigation, which according to P. Welmans[**]) gives trustworthy results. In this method 5 grammes of chocolate or cacao are de-fatted with ether and dried, then rubbed down in a mortar with a little water, and levigated with about 100 ccm of water in a cylinder. The liquid is allowed to rest for sometime and the suspended matter poured off almost to the sediment, which is again shaken up with fresh water, allowed to settle and the operation repeated until all the fine particles have been floated off and the water over the sediment no longer becomes cloudy, but remains clear after the coarser and heavy particles have settled down. Welmans carries out the levigation method in such a manner, that the residue of the agitation method (see page 222), after removing, as much as possible, the ether solution of fat and drawing off the aqueous liquid, is levigated in an Erlenmeyer litre flask with ordinary water and subsequently with 150 ccm of distilled water as above described. Whichever levigation method has been followed, the sediment is collected on a watch glass, dried and weighed. The weighed residue is then softened with caustic soda and glycerin, and examined under the microscope. Attention is to be given as to the presence of any cotyledon particles which, through insufficient grinding, have escaped separation by levigation, also whether particles of husk or epidermis or germ preponderate. With proper levigation only traces of cacao substance, especially here recognizable by the cacao starch, should be observable. The sand, which always adheres to the shells in the fermenting and drying operations, is also easily recognized and many indications as to the nature of the article under investigation can be noted by the use of a simple magnifying glass applied to the washed residue on the watch glass before drying.

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[*]) Zeitschrift für öffentliche Chemie 1899. No. 2, page 29.

[**]) Zeitschrift für öffentliche Chemie 1899. No. 22, page 479.

Examined in that way, a sample of "so called cacao from unshelled beans" gave 6 to 8 percent of husk; usually good cacao powder shews a maximum of 2—5 percent of husk. The result obtained by the levigation method can be controlled by the previously mentioned methods of Weender or Filsinger, as well as by determination of the silica in the ash (compare page 220).

Latterly, the admixture of cacao husk with the cheaper kinds of cacao powder has largely increased, therefore the determination of the amount of husk in cacao preparations is of especial importance.

k) Determination of sugar. There are three methods for the quick determination of sugar, two of which are polarimetric and the third by taking the specific gravity of a solution obtained by shaking up the cacao with water. It is well to note, that in all these methods the result includes the normal amount of sugar in cacao, which according to Welmans*) amounts to 0·75—2 percent in cacao and to 0·4—1·0 percent in chocolate. That source of error is of no great importance, as it is compensated in the course of the operation, as Welmans has shown, so that these methods are of service.

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*) Pharmazeutische Zeitung 1889, pag. 847.

The official method for determination of sugar in chocolate according to the German decree of 31. May 1891 (Appendix E, Berlin 1892) is as follows:

"13·024 grammes of chocolate are damped with alcohol, then warmed for 15 minutes with 30 ccm of water on the water bath; while still hot it is poured on to a wet filter, the residue again treated with hot water, until the filtrate nearly equals 100 ccm. The filtrate is to be mixed with 5 ccm of basic lead acetate solution, allowed to stand for ¼ hour, then clarified with alum and a little alumina, made up to a definite volume (110 ccm) and polarized."

Another polarimetric method, recommended by Woy*), is carried out as follows: Two portions of half the normal weight (13·024 grammes) of rasped or shaved chocolate are placed respective in a 100 ccm and 200 ccm flask, moistened with alcohol, then treated with hot water and agitated until the sugar is dissolved. 4 ccm of basic lead acetate solution are added to each flask, by which means the chocolate in suspension loses its viscosity. After being cooled, the solutions are made up to the marks, well mixed and filtered. Two quickly filtering liquids are thus obtained, which are then polarised in 200 mm tubes. With chocolate containing meal, the temperature of the water must not exceed 50° C. From the two polarisations, the following equation results: $a (100-x) = b (200-x)$ in which a and b are the results of polarizing, and x the volume of the insoluble substances, including the lead precipitate, contained in the half normal weight. The product of the equation gives the amount of sugar present. Woy's method has the great advantage of avoiding the error due to the volume of the undissolved cacao and the lead precipitate.

The third method proposed by the author**) is as follows:

50 grammes of chocolate finely divided with an iron grater or rasp are treated with exactly 200 ccm of cold water, with frequent agitation, for 4 hours, then poured on to a previously

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*) Zeitschrift für öffentliche Chemie 1898, page 224.

**) Untersuchungen über Kakao und dessen Präparate, page 48.

damped and well wrung pointed bag, and the specific gravity of the filtrate taken in an araeometer, specially constructed, according to the author's direction, for that purpose by the firm of Greiner in Munich. On the scale of the araeometer is given the percentage amount of sugar in the chocolate, from 5 to 5 percent, with subdivisions of one percent, so that the reading can be quickly made, without correction. The accuracy of this simple method has lately been confirmed by the investigation of Welmans.*)

In the determination of sugar by weight, the chocolate is first de-fatted with ether, the sugar extracted with alcohol, then inverted, the inverted solution treated with Fehling's solution and the copper precipitate weighed; it cannot be recommended as it is troublesome and has too many sources of error.

l) Determination of albuminates. The determination of albumin is frequently required in the analysis of cacao powder; it is necessary for ascertaining its nutriment value. It requires the determination of the total nitrogen by Kjeldahl's method (see page 56). From the result so obtained is deducted the nitrogen equivalent to the diureïdes present and the difference, multiplied by 6·25, gives the amount of albumin.

In rare cases a large amount of albumin may be due to admixture to the chocolate of earth-nut cake, or gelatine. On the detection of the latter adulteration see p. 219. Earth-nut cake according to Bilteryst**) can be recognized by its high albumin content, amounting to 45—47 percent.

II. Microscopic-botanical investigation.

Cacao is to no great extent particularly characterized anatomically. The parenchyma cells are chiefly to be noticed, containing either fat, albumin (protoplasm) aleuron granules, pigment, or cacao starch. The starch, as already remarked, consists of especially small globular granules, mostly separate, but also two or three adherent. It is somewhat more difficult to gelatinize than other kinds of starch, and it is coloured blue by iodine somewhat more slowly than many other starch granules, especially in the preparations containing fat. Cacao preparations which have been rendered "soluble" by fixed alkalies, differ in that respect; according to Welmans, iodine first forms colourless iodine compounds, and not until the alkali has been saturated, is the blue colour developed. In such cases, care must be taken, that an excess of iodine is present. In estimating the amount of foreign starch, great care must be taken that the conspicuous bluish-black granules of the foreign starch, which immediately strike the eye, are not over estimated, which may easily occur. For control observations, mixtures containing various known amounts of starch should be tried comparatively. The pigment cells and the epidermis with the Mitscherlich's particles should be noticed as well as the characteristic globoids, which occur in the ash of the cotyledon tissues (compare page 66). The outside shell, more or less woody according to the origin of the bean, consists of four layers of cells; this is best recognized by the large cells of the principal tissue, which are distinguished by the form as well as by their thickened side walls from the tissue of the cotyledon. Another characteristic of this layer consists in the large number of coarse spiral vessels, which exceed those of the seed lobes in size, and finally, the inner elements of the stone cell layer, which on account of their limited development are however seldom to be discovered. The smooth, fine brown coloured, and light refracting fragments, which frequently appear quite structureless and have their fibrous character made perceptible only after treatment with caustic alkali, must be regarded as characteristic of the inner part of the husk or the seed membrane. The best observing medium is a solution of chloral hydrate or almond oil, as well as dilute sulphuric acid and glycerine.*) The substance is always to be de-fatted with ether, before the microscopical examination. A complete extraction of the fat, according to Welmans, can occur only with exceedingly thin cuttings, in which every cell of the section would be operated on, or in powdered preparations, when the cells have been completely torn asunder by mechanical pulverization. The fat is not extracted by solvents from intact cells, as the cell walls are impermeable by them.**)

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*) Pharmazeutische Zeitung 1898, page 847.

**) Journal de Pharmacie et Chimie 1877, II. pag. 29.

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*) Compare: Welmans, Zeitschrift für öffentliche Chemie 1900, page 480.

**) The reader, who would further consider the form elements of cacao, is referred to the excellent paper by Py in the Journal de Pharm. et Chimie 1895. Vol. I Page 593.

The detection of foreign starch is possible only by use of the microscope; by means of standard preparations an approximate estimate may be made as to the amount and kind of meal added.*) The examination for starch is especially facilitated by H. Leffmann and W. Beam's**) centrifugal method: the sample suspended in water is subjected to rotation for a short time in the centrifugal apparatus. The presence of foreign starch is shown by a white layer in the sediment. This layer can be collected and microscopically examined for foreign starch and husk. In the case of cacao preparations, it is always well to distinguish between un-important traces and quantities that justify objection.

A means of detecting tragacanth in cacao preparations, has lately been described by Welmans.***) According to him, 5 grammes of the cacao preparation are to be mixed with sufficient dilute sulphuric acid (1 : 3) to form a thick pulp, then with 10 drops of solution of iodine (in potassium iodide) and some glycerine. A portion of the mixture is examined under the microscope (enlarged 160 times). The entire field of view now appears to be thickly sown with countless blue dots, some globular, others irregular, among which are especially to be noticed the large tragacanth cells, resembling potato starch, which are not seen in cacao powder that is free from tragacanth, when similarly prepared as an object; the small blue dots, due to cacao starch, are visible only in the densely occupied portions.

An admixture of the carob, which has been seldom observed, can be easily recognized under the microscope by the characteristic reddish wrinkled tubes of the fruit pulp, which are also coloured violet by treatment with a warm solution of caustic potash.

The presence of earth-nut or earth-nut cake can be detected by the aid of the microscope on treatment with chloral hydrate, by the characteristic saw toothed epidermis cells of the husk of arachis seed.

Hazelnut and walnut pulp, so far as they are to be met with in cacao preparations, can be distinguished under the microscope by shreds of the tissue of the seed husks, in which broad streaks of spiral vessels, lying close on one another, are distinctly prominent. If in addition the woody fruit shell be admixed, it can be detected by the great number of stone cells.

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*) Compare: E. Guenez, Revue internationale des falsifications des denrées alimentaires 1895. Vol. VIII, pages 83—84.

**) Chemiker-Zeitung 1890. Vol. 14, Rep. page 48.

***) Zeitschrift für öffentliche Chemie, 1900, page 480.

III. Sampling.

Sampling is of much importance in the analytical examination of cacao preparations. That is especially the case with cacao powder, through variation in the amount of moisture and the unequal fineness of the powder. The sample of powdered cacao being frequently taken from a large stock, the sampling from different parts is rendered more exact if equally large quantities are taken and mixed through a sieve; the material for analysis should then be filled into metallic boxes or glass bottles, with well fitting stoppers. The dispatch of samples in paper wrappers or in card board boxes cannot be recommended, as they may be affected by dampness or evaporation, according to the weather and the temperature of the air.

The quantity required for an examination of chocolate, cacao powder, cacao fat and coating mass is 100 grammes, but that should be increased to 250 grammes if it be necessary to test for foreign fat in chocolate, or to examine the ash constituents in cacao powder. In other respects, the directions issued by the official representatives of trade, for the guidance of public analysts in the taking of samples, are to be observed.

IV. Definition of cacao preparations. Adulteration and directions for its detection; judging of cacao preparations.

For a definition of cacao goods the Union of German chocolate manufacturers has for some years past adopted the following formulæ, to which the author completely adheres because they satisfy, from a scientific and practical point of view, all reasonable claims and correspond with the progress effected by the great development of machinery. Those definitions are supplemented only in some unimportant points so as to include certain new conditions.

a) Chocolate is a mixture of roasted and shelled cacao with sugar (beet root sugar) and an addition eventually of cacao butter, vanilla, vanillin, cinnamon, cloves or other spices *or their essential oils*.

b) Cacao mass: The ground product of roasted and shelled cacao beans, moulded.

c) Cacao-powder: The product obtained after pressing out a portion of the cacao butter from roasted and shelled cacao beans. *Soluble cacao is prepared by treatment with alkalies, steam pressure, water, or by some other suitable process.*

d) Cacao butter: The fat obtained by pressure *from roasted, shelled cacao.*

e) Chocolate-surrogate or "suppen-powder": A mixture of a small quantity of cacao with cacao waste and a larger quantity of sugar (beet root sugar), meal, spices, and not exceeding 1½ percent of a harmless colouring material.

Cacao goods undergo much adulteration everywhere. The following table (see page 233) shows the authenticated fraudulent admixtures to cacao, and in the last column is mentioned the page in this book, where the process for detection is described in detail.

Standards for the valuation of cacao goods are arrived at partly from the definition formulæ and partly from general information as to the various forms of adulteration. Those standards are given to some extent on the authority of the previously mentioned work by Filsinger, which was prepared to serve as a guide for the „Reichsgesundheitsamt".

Chocolate, cacao mass and cacao powder (de-fatted, soluble cacao) should contain no foreign vegetable admixtures, such as starch, meal, earth-nut-cake, hazel nut or walnut pulp, no cacao husk or waste, nor any foreign mineral ingredients or foreign fat. Chocolate containing an addition of meal must bear, on the wrapper, a distinct declaration of such mixture. The presence of cacao husk is detrimental to the nutritive value of the cacao preparations; husk is of little value for human consumption, as it consists, to a large extent, of woody substance mingled with much earth and sand. The removal of husk at the present time is so easily accomplished by the perfected cleaning machine, that in carefully purified cacao there should be only a very small amount of husk. Above such amounts, the admixture of husk, even when declared, is inadmissible in

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*) The italics have been introduced by the author.

Name of the cacao preparations	Adulteration	Detection	Reference
Chocolate mass **Cacao mass** **Coated Goods** **Couvertüren** **Chocolats fondants**	Meal (kind not stated)	a) Microscopically	228
		b) By excess in glucose	60
		c) By decreasing the amount of ash	64. 219
	Cacao husks and saw dust	a) By increasing the amount of ash and the amount of silicic acid in the ash	64 219. 220
		b) Method of levigation	71. 225
		c) Determination of fibre	62. 225
		d) Microscopically	229
	Foreign fats and oils.	a) Melting point	38
		b) Iodine value	41
		c) Saponification value	41
		d) Refractometer test	42
		e) Björklund's test	39
	Bad (rancid) Cacao-butter	a) Acid value	42
		b) Reichert-Meissl number	42
	Forbidden colouring matters: Yellow ochre Red ferric oxide Brick dust Coal	Increase in the amount of ash	64. 219
only observed in „Suppen pulver“;	Cacaolol		234
only used to imitate the ash of chocolate cigars;	Zinc white and heavy spar	Analytically in the ash	
	Besides inorganic weighting material Sand Clay	Increase in the amount of ash	64. 219
	Dextrin	Polarisation by Welmans' process	223
	Excess of Sugar	a) Polarimetric test	227
		b) Aräometric test	227
		c) Decrease in ash	64. 219
	Excess of Cacao butter	Determination of amount of fat	36. 221
	Excess of water	Determination of moisture	218
	Gelatine	Picric acid test and albumin determination	56. 219
	Tragacanth	Microscopically	230
	Earth-nut	Microscopically	230
	Earth-nut-cake	Determination of albumin	56. 228
	Walnut-andhazelnutpulps	Microscopically	230
Cacao-Powder	Husk Foreign fat Meal	As with chocolate	—

cacao manufactures. An addition of spices or of the corresponding ethereal oils is allowed in chocolate, also roasted almonds or nuts, which are especially introduced for "coating masses", "croquants", etc. etc.

Chocolate glazing mass or coating mass (couverture) must answer the same requirements, as to purity, as chocolate and must especially contain neither foreign fat nor cacao husk. Cacao husk, moreover, impedes the coating, since the sharp edged particles of husk cause a rapid cooling of the coating mass. The addition of even a small amount of sesame, or cocoa nut oil (5 percent), spoils the flavour of chocolate when kept and imparts a disagreeable after taste.

The use of colouring matters (mineral and coal tar colours) is inadmissible, when they are not intended for decoration, but as fraudulent substitutes for cacao; those colours also are excluded even for decorative purposes, which are doubtful from a hygienic stand point.

As a fraudulent substitute for cacao red must be mentioned cacaolol, which has been investigated by Posetto.*) It is a solution of an artificial colouring substance in oil, which is added to chocolate containing much starch, in order to produce a fine reddish brown colour. In the determination of fat, the oil would be extracted by ether, and the ethereal extract, usually colourless, would appear greenish yellow. When saponified by alcoholic potash, the colouring material is removed by ether and it yields a characteristic blue colour with sulphuric acid. Wool is coloured by it in an alkaline bath and the colour removed in an acid bath. These properties distinguish the artificial colouring matter very easily from natural cacao red.

Admixtures of fat, gelatine, tragacanth or dextrin are also inadmissible, as they are intended to conceal an addition of water.

Cacao mass contains on the average 3—4 percent of ash and 50—55 percent of fat.

Cacao powder contains a varying, that is, an arbitrary amount of fat and, consequently, the amount of ash will vary according to the quantity of fat expressed. It is therefore recommended to state the ascertained amount of ash either in reference to cacao mass containing 50 percent of fat, or to the fat-free material. For practical purposes, the calculation is best made on the fat-free dry substance, as the preparations sometimes contain a considerable amount of moisture. Cacao powder, which has been rendered "soluble" without the use of potassium, sodium or magnesium carbonates, contains the same amount of ash as de-fatted cacao mass; whereas, when it has been made "soluble" with fixed alkalies, the ash is much larger. The amount of ash in de-fatted cacao powder should not much exceed 3 percent. The mixture of sugar with cacao powder is inadmissible.

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*) Giornale di Farmacia di Torino 1901, page 193.

Chocolate, chocolats fondants and "couvertures" contain varying amounts of sugar and fat, so that it is not possible to fix ash constants for those preparations.

For the chemical estimation of chocolate, an agreement, as to the minimum amount of cacao, is to be desired. It should at the same time be settled, that in good chocolate neither the sugar nor the fat should exceed certain percentages. The excessive addition of cacao butter to chocolate has latterly reached great dimensions, for frequently are to be found in commerce cacao preparations described as "guaranteed" pure cacao and sugar which contain only 15—20 percent of cacao mass with 50 percent of fat.

A minimum of 35 per cent cacao mass in chocolate has been fixed by the German Federal Council for drawback in the case of chocolate for export.

On the assumption that raw cacao contains, on the average, 50 percent of fat, the cacao contents in chocolate are equal to twice the quantity of fat-free cacao mass.

XVI. Official enactments respecting the trade in cacao preparations.

The trade in cacao preparations has up to the present time been subject to official regulations in only two states, namely in Belgium and Roumania. The essential provisions of the official orders are given below, as they are especially of importance for export goods.

The Belgian Royal Decree of the 18. November 1894, based on the food law of the 4. August 1890 and articles 454 to 457, 500 to 503 and 561 of the Royal Code, provides as follows, according to the "Moniteur Belge" of the 3. and 4. December 1894:

Art. I. It is forbidden to sell, to expose for sale, to be in possession of, or to offer for sale, under the designation "entire cacao", any other production than the fruit of the cacao tree, raw and whole, or prepared by roasting, shelling, grinding, with or without addition of spice and finally moulded in blocks, or tablets, or converted into powder.

It is lawful to sell, to expose for sale, to have in possession, or to offer for sale, under the designation "cacao or cacao powder", cacao, from which a part of its butter has been expressed, provided that the proportion of this latter ingredient be not reduced below 20 percent; under the designation "alkalised cacao (cacao alcalinisé)", cacao, in which the amount of alkali has been increased by a special treatment; provided that the increase, calculated as alkaline carbonate does not exceed 3 percent of the total weight. The distinctive term "alkalised (alcalinisé)" is not required in the case of goods in stock, or intended for export.

Cacao, which has been prepared in other ways than those mentioned, can only be sold or exposed for sale, kept in stock, or offered for sale under a label, which, in addition to the word "cacao", distinguishes in distinct form the special mode of preparation, or under a label, which does not contain the word "cacao".

The word "alkalised", or other words announcing an intentional alteration in the natural composition of cacao, must be marked on the label in legible characters as large as the word "cacao".

Cacao, to which a proportion of alkali has been added, exceeding 3 percent, is regarded as unwholesome. The sale, the keeping for sale, the possession of, or offering for sale of such cacao is forbidden.

Art. 2. It is forbidden under the single term "chocolate" to sell, to expose for sale, to have in possession, or to offer for sale any production which is not exclusively composed of shelled cacao in the proportion at least of 35 percent and ordinary sugar with or without an addition of spice. Preparations which, although containing at least 35 percent of shelled cacao, contain other substances besides those previously mentioned must be sold, exposed for sale, stocked or offered for sale, only under a label which, in addition to the word chocolate, must describe in distinct form the nature of those other ingredients, in characters as legible and as large as the word "chocolate". In regard to chocolate in tablets, any irregular composition of the preparation must be distinctly stamped on each tablet.

Preparations containing less than 35 percent of cacao may be sold only under the description of "cacao bonbons", or under some other name, in which the word "chocolate" must be excluded and such preparations must be so exposed for sale, kept in stock or offered for sale.

Art. 3. The statements in articles 1 and 2 respecting the label for preparations of irregular composition must be made in the invoices relating to them.

Art. 4. The receptacle or enclosure, in which cacao and chocolate is sold, exposed for sale, kept in stock for sale, or offered for sale must bear the name of the manufacturers, or of the firm, as well as the domicile of the makers or sellers, or at least a registered trade mark.

Art. 5. The enactments of this decree, so far as it relates to chocolate, are applicable only to ordinary chocolate in tablets, blocks or powder and in balls, but not to chocolate crêmes or the various preparations of confectionery (pralinés. pastilles and so forth).

Art. 6. Infringement of the enactments of this decree is subject to punishment as provided in the law of 4. August 1890, without prejudice to the application of the penalties stipulated in the penal code.

Art. 7. The minister for agriculture, industry and public works is empowered to carry out this decree which comes into force on 1. April 1895.

The Roumanian Royal Decree respecting surveillance of the wholesomeness of food and drink, and of the trade in food, articles 154, 155, 156, and 157 of the sanitary law of the 11. September 1895, is according to the "buletinul directiunei generale a serviciului sanitar" 1895 no. 18 and 19, page 277, to the following effect:

Title XIII. Article 137.

Under the description cacao no other product is to be sold, exposed for sale, or stocked, but the seed (bean) of the fruit of the tree "theobroma cacao". It can be brought into trade in a raw state, roasted, or after roasting, pounded.

Under the description of de-fatted cacao powder may be sold cacao powder, from which a part of the butter has been expressed, which still contains at least 22 percent of cacao butter. Under the description of soluble cacao powder may be sold the powder of roasted cacao, which contains not more than 2 percent of potassium or sodium carbonate.

Art. 138. It is forbidden to sell to expose for sale, cacao artificially coloured, or mixed with starch, foreign fats or other foreign substances. The same prohibition applies to the mixing of cacao powder with the powder of cacao husk; such admixture is not permitted to the extent of more than 15 percent of pounded husk.*)

Art. 139. Under the description "chocolate", may be sold and exposed for sale only that made from roasted and pounded cacao beans and sugar, with or without the addition of aromatic constituents, such as vanilla, cinnamon and similar wholesome and harmless dietetic substances.

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*) Accordingly, the Roumanian law allows the sale of a cacao powder prepared from unshelled cacao and forbids only a further addition of husks. Note by the Author.

Art. 140. The preparation and the sale, as well as the exposure for sale, of chocolate made from cacao which does not correspond with the enactments of articles 137 and 138 of this decree, or of chocolate, which has been mixed with meal, starch, mineral constituents, artificial colouring substances, and other foreign materials, are forbidden.

An official regulation of the trade in cacao preparations may shortly be expected in Switzerland and Austria.

What Switzerland desires has meanwhile been expressed by the Swiss society of analytical chemists, at the instigation of the Swiss Department of the Interior, in the "Schweizerisches Lebensmittelbuch", in which methods and standards for the investigation and determination of articles of food, including cacao preparations, are laid down. That work has been of use in the enforcement of the Swiss food law, also as a precedent in the valuation of articles of food in general trade, and it might well, eventually, serve as a basis for the contemplated later decree. From the cacao section of this work the main points are taken as follow:

Definitions.

1. Cacao mass is obtained by grinding and moulding roasted and shelled cacao beans, without any addition or abstraction of cacao butter.

2. De-fatted cacao is cacao mass, which by means of hot pressure has been deprived of 20—35 percent of cacao butter.

3. Soluble cacao. The roasted cacao beans are treated with alkaline carbonates (generally potassium carbonate) ammonia, or steam under pressure, whereby the cell tissues are disintegrated and the albuminous substances transformed into a soluble modification peptone(?) and an alkaline albuminate.*)
After that treatment, the cacao beans are dried, finely divided, de-fatted and pulverized.

4. Chocolate is the description of a mixture of cacao and sugar, sold either moulded or in a powdered form. The amount

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*) "Albumose" would be more correct, or better omitted, as nothing has been thoroughly established as to this alteration of albuminous substance. (The Author.)

of sugar varies from 40—70 percent. All admixtures of other ingredients than cacao, sugar and the permitted spices, must be regarded as adulteration.*)

5. Chocolate and cacao (in powder or moulded) can be made aromatic with the following substances: Vanilla, benzoin, tolu or peruvian balsams, cinnamon, cloves or nutmeg.

6. Chocolates fondants consist of chocolate with an exceptional amount of fat and sugar.

7. Milk chocolate is a preparation made from cacao, milk and sugar. It must not contain preservatives like boric acid, borax, formaldehyde, or derivatives of the aromatic series which are not allowed to be added to milk. It occurs in commerce in tablet form and in powder.

8. Couverture or coating mass is a mixture of cacao, sugar, spices, with almonds and hazelnuts. It is almost exclusively used in confectionery in the preparation of bonbons.

9. Medicinal chocolate is chocolate or cacao with an addition of medicaments.

Tests and determinations always to be carried out:

1. The sense tests (smell, taste, etc.).
2. Reaction.
3. Microscopic examination.
4. Test of the fat.
5. Determination of the fat.
6. Determination of sugar.
7. Determination of ash.

Determinations eventually to be made:

8. Determination of the water.
9. Determination of the theobromine.
10. Determination of the starch.
11. Determination of the cellulose.

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*) Accordingly, an addition of cacao butter might be objected to; by admitting 70 percent of sugar an addition of cacao butter is absolutely necessary and this lowers the amount of cacao mass to 10—20 percent. (The Author.)

Characteristics.

Unripe, badly fermented cacao beans, as well as those that are worm eaten, mouldy or sea damaged in transport should be excluded from the manufacture.

Preparations from such beans have a disagreeable taste, which cannot be completely removed in the various stages of the manufacture. The use of beans of that nature is to be considered as an adulteration. The taste, microscopic examination, as well as, finally, the determination of sodium chloride will serve for their detection.

Good chocolate has a fine brown colour. Grey or spotted chocolate is to be objected to. It can become grey or spotted through age, dampness or heat. At the ordinary temperature, the fracture of good chocolate is hard, vitreous and uniform. The condition of the fracture is a good indication of the working up of the raw material.

Cacao or chocolate, which forms a thick pulp on being boiled is to be suspected of being mixed with meal, starch, dextrin or gum.

The following are to be considered as adulterations:

1. The addition of cacao husk, foreign husks, saw dust.

2. Foreign starch, corn meal, chestnuts, roasted acorns, dextrin, gum.

3. Mineral substances, such as ochre, clay or sand.

4. Substitution of cheaper fat for cacao butter, such as beef and pork fat, almond oil, poppy oil, cocoa nut oil or vaselin.

Constants.

1. Cacao mass:

Ash	Maximum 5 %	(Porto Cabello 4·65 % *)
	Minimum 2 %	(Surinam) 2·25 %)
Cacao butter	Maximum 54·5 %	(Machala 54·06 %)
	Minimum 48·0 %	(Porto Cabello 45·87 %) *)

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*) These numbers require revision as they do not agree with others that are to be depended on. (The Author).

2. Cacao fat: Melting point 29—33·5° C.; solidifying point 24 to 25° C., refraction at 40° C. 46—49;*) iodine value 34—37; saponification value 192—202.

3. Soluble cacao: The addition of alkaline carbonate shall not exceed 3 percent (calculated on the de-fatted cacao powder). In no case shall the ash amount to more than 8 percent; this constant is not in contradiction of the above stated maximum amount in cacao mass, since soluble cacao is always prepared from a mixture of several kinds of cacao, and the amount of ash in such a mixture (notwithstanding it is partly de-fatted) does not exceed 5 percent.

4. Chocolate: At present no constant has been fixed for the cacao and sugar; nevertheless the fat and sugar together in good chocolate (fondants excepted) should not exceed 80 to 85 percent; the remaining 15—20 percent should consist of fat-free cacao mass. The amount of ash in good chocolate is not higher than 3·5 percent.

5. Milk chocolate: The constituents of this preparation require to be thoroughly dry. Should the amount of water exceed 5 percent, the preparation is to be objected to as it is no longer durable.

6. Chocolat à la noisette, oat-chocolate, meat cacao, etc. and medicinal chocolate. The investigation shall be extended in two directions:

1. It shall be ascertained whether the constituents, as described on the label, are of good quality.
2. Whether only the constituents are present which are stated on the packet.

"Medicinal chocolate shall have stated on the wrapper the nature and amount of its constituents."

Austria has for some years (from 19. Januar 1896) possessed a law on the trade in food and alimentary substances, but no special regulations as to single articles have so far been the result and these will only gradually be made. However, as in Switzerland, a voluntary society the "Vereinigung Oesterreichischer Nahrungsmittel-Chemiker und Mikroskopiker" has drawn up a scheme for a "Codex alimentarius austriacus". At the same time, the work of the codex commission can only be regarded as of a private nature and cannot consequently be officially recognized. It is however accepted by all Austrian chemists and has the same effect, indirectly, on legal decisions as the opinion of an expert, especially as each article has been drawn up by some of the most distinguished Austrian authorities. The most important points in the codex are therefore given in connection with this subject, although many of them it is anticipated will undergo some alteration before they become legal, as since the appearance of the codex, many of the methods of investigation there described have been altered.

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*) Requires to be revised. (The Author.)

I. Cacao mass.

Definition. It consists of a uniformly fine mass and when warmed of a thin paste, which has been prepared from completely shelled cacao kernels.

Constituents. Cacao mass contains the same chemical constituents as decorticated cacao beans.

The microscopic test should only show the presence of the tissues of the seed kernel with exclusion of the radicles, which should have been removed in the preparation.

The ash should not exceed 3·5 percent,*) the fibre 3 percent,*) and the starch 10·5 percent. The fat amounts to 48 to 52 percent.

II. Cacao powder.

(Powdered cacao, de-fatted cacao, soluble cacao.)

Definition. It consists of the powder obtained from the steamed, treated or unaltered cacao mass after expressing at least one half of the fat and grinding and sifting the residue.

Properties. Cacao powder shall give by simple boiling with 20 to 30 times its weight of water a mixture in which no lumps can be seen and after one minute standing it should give no sediment.**) If this should occur, the sediment is to be examined microscopically.

Cacao powder shall be ground and sifted as fine as flour and shall not give more than 5 percent of residue when sifted through a No. 12 fine gauze sieve.

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*) These Values require revision, as usually only the less valuable cacaos like St. Thomé, Domingo, Cuba, Haiti are under 3·5 percent of ash, whilst Ariba, Porto Cabello, Caracas, Guayaquil are decided higher; the same with the crude fibre.

**) Requires to be revised, for by boiling 7·5 grammes of cacao with 250 grammes of water a sediment always forms after a minute standing. (The Author).

The chemical composition of a cacao powder depends on the extent of de-fatting. 100 parts from which 30 parts of fat have been expressed, as is usually the case, should give a cacao powder, containing:

30 percent fat, 5 percent ash,*) 3:5 percent fibre,*) 13 percent starch.

The amount of water should not exceed 6 percent.

The fat should be pure cacao butter.

The addition of alkalies is not allowed.

The microscope test as in I.

III. Chocolate.

Definition. The term chocolate is applied to a uniform mixture of white sugar (Raffinade, Pilé, Melis) and cacao mass.

The completely uniform pasty mass, when warmed, is allowed to set in moulds and then forms pieces of fatty appearance, finely granular or close fracture (tablets, blocks).

Good chocolate consists of 40 to 50 percent of cacao mass and 50 to 60 percent of sugar.

It may also contain a small amount of harmless aromatic substances.

Should the sum of the cacao fat and sugar in chocolate amount to over 85 percent, it is termed "Sweetmeat chocolate", and should the sum of those ingredients be more than 90 percent, the chocolate is to be termed "very sweet".

All the ingredients in chocolate, after deducting the sugar, shall be present in the same relative proportion and in the same condition as in pure cacao mass (compare I).

Sweetened chocolate is an exception, in so far as it has had in its preparation an addition of cacao butter. Fine kinds are also prepared with an addition of de-fatted cacao.

Unmoulded chocolate or chocolate powder shall answer to the same requirements.

IV. Cacao surrogate and chocolate surrogate.

Definition. Cacao preparations containing meal are to be described as surrogates.

The addition of other substances than meal is inadmissible.

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*) Requires revision; see pages 221 and 205 for Filsinger's results for crude fibre. (The Author.)

Absence of cacao husk is also required as in I, II, III.

Mixtures of cacao powder, sugar and meal are also to be regarded as surrogates.

The extent of the addition of meal is to be distinctly noted by the seller on the article sold.

V. Couverture (coating mass).

Definition. This includes various preparations of pure cacao butter and chocolate (or mixtures of chocolate with cacao butter and cacao mass), which form a thin liquid, when warmed, and are used for coating or pouring over confectionery. All other substances (roasted hazel nuts or almonds and the like) shall be declared.

Investigation.

To be carried out without exception with all cacao preparations:

1. Determination of fat. The fat is extracted from the dry substance which has been mixed with an indifferent substance (sand) by pure and absolutely dry ether (distilled over sodium) or by petroleum ether. Cacao mass and chocolate must first be shaved or rasped.

2. Test of the fat.

a) Determination of the melting point in a capillary tube (three days after the fat has been melted into the tube).*) Pure cacao butter usually melts at 33° C.

b) Determination of the iodine value; usually 35·0 with pure cacao fat.

It is further recommended to make a refractometric determination, which in a Zeiss butter-refractometer must be 46·5° C. at 40° C.

3. The microscopic test of the substance, from which the fat and the sugar have been removed.

The following are also essential:

I. With cacao mass.

The determination of fibre and ash.

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*) Requires revision, compare page 38.

II. Cacao powder.

Determination of moisture at 100° C., of the fibre and ash and examination of the ash (quantitative determination of phosphoric acid and potash).

III. Chocolate.

Determination of the sugar by polarisation of the aqueous solution.

IV. Surrogates.

Determination of the starch.

If it is considered necessary to proceed further, then:

1. Determination of theobromine by a modification of Wolfram's method, the method employed is to be exactly stated.*)

In the determination of starch, the gelatinization is to be carried out under steam pressure and the inverted sugar gravimetrically determined with Fehling's solution.

An opinion of the quality of the preparation can be formed from the taste, smell and colour of the sample, when boiled with water.

In default of particular laws being valid within the United Kingdom adulteration of cacao preparations is subject to the articles of the "Sale of Food and Drugs Act 1875" and of the "Sale of Food and Drugs Act Amendment Act 1879". An excellent consolidation and treatise of the relations of these acts to one another are contained in the handbook of Chs. James Higginson, entitled "Food and Drugs"**) to which I refer parties concerned.

Similar conditions of things exist in the United States of America, but there the judgment is made worse by the circumstance, that, in general, uniform laws against adulteration of food products are not to be met with. For over a decade, attempts have been made to have Congress enact a law against the adulteration of foods in the Territories and for the regulation of inter state traffic in food etc., but up to the present all attempts have failed.

Bills are now pending in the National House of Representatives (Hepburn Bill, H. R. 3109) and the Senate (Hansbrough Bill, S. 3342) "for preventing the adulteration, misbranding and imitation of foods, beverages, candies, drugs and condiments in the District of Columbia and the Territories and regulating inter state traffic therein, and for other purposes". In connection with the act of August 1890, regulating the inspection of meats for exportation from the United States, provisions are enacted making it unlawful to import into the United States "adulterated or unwholesome food or drugs or spirituous, vinous or malt liquors containing any injurious ingredients".*) Digests of all the "pure food" laws are contained in the Senate Document No. 141. From this document it will be seen, that all the states of the United States have laws bearing more or less stringently on the adulteration of foods. The adulteration of food (accordingly of cacao preparations) with harmful substances is mentioned generally and prohibited. Most of the State laws mention specifically "Imitation-butter", "Candy", "unwholesome food", "Milk", "Liquors", "Vinegar", but "Cacao" is but seldom referred to by name; Illinois law only states the ingredients which may be used in preparing chocolate, cocoa etc.

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*) We would prefer Eminger's method. (The Author.)

**) London, Effingham-Wilson 1902.

In Germany, unfortunately, there is at present no law, which regulates the trade in cacao goods. It is true, the decree of the 14. Mai 1879 exists respecting the trade in food, alimentary substances and comestibles, which contains the usual penal enactments in regard to adulteration of food materials offered for sale. The enactments are supplemented with data relating to the administration of the law, among which a definition of chocolate, as well as the means of judging as to the quality or its adulteration, are treated of. But those data do not in all respects apply to existing conditions, nor do they deal fully with the question as to what admixtures are to be permitted or prohibited, for in the introduction to the appendix A, there is the following statement:

"Like the former provision, the present one is not intended to be an exhaustive description of all subjects of the kind referred to, but a compilation of those examples which appear to be especially calculated to serve as an illustration of legislative requirements."

The data referred to have not an officially authoritative significance, and they cannot be regarded as having established validity in connection with the administration of the law by the police or by legal authorities. (See: Commentary by Meyer-Finkenburg, page 116.)

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*) Senate Document No. 141.

Even the complete publication of the "Vereinbarungen zur einheitlichen Untersuchung von Nahrungs- und Genussmitteln sowie Gebrauchsgegenständen für das Deutsche Reich", collected at the instance of the national health department, will not have the effect of giving certainty in the law relating to the manufacture of chocolate. That section of the "Vereinbarungen", which deals with cacao products, has been just published,*) but the conditions in Germany are at present only similar to those existing in Switzerland and in Austria. The "Vereinbarungen" are nothing more, than a valuable semi-official guide for the valuation and examination of food and comestibles, the provisions of which, not being obligatory, have no legal effect.

The consequence is, that the prosecution of various manipulations which certainly deserve to be objected to, such as the preparation of cacao or chocolate from undecorticated beans would be difficult to carry out. The Association of German Chocolate Manufacturers has protested against that unsuitable state of affairs, and since a remedy is to be looked for only from the enactment of a law regulating the trade in cacao products, that association prepared a draft act, at its 17. annual meeting at Leipsic on the 15. January 1893, and has submitted it to the government health department.

That draft is in accordance with the provisions printed on pages 231 & 232 a—e. The provisions of the association in reference to the trade in cacao products also contain the following paragraphs:

§ 2.

It is not to be considered adulteration or counterfeit, within the meaning of the law (§ 10) relating to trade in food materials, comestibles or articles of consumption (of 14. May 1879, Reichsgesetzblatt page 145):

1. When the productions referred to under a, b, c pages 231 & 232 are mixed with meal or other substances for medicinal purposes, provided, they are of a character by which they are distinctly recognisable, or are kept in stock or offered

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*) Vereinbarungen etc., Heft III., Berlin, Julius Springer 1902 pag. 68—75.

for sale under a designation distinguishing them from chocolate, cacao mass, or cacao powder.

2. When covering mass (couverture) or sweetmeat chocolate is mixed with burnt almonds or hazel nuts to the extent of 5 percent.

§ 3.

Adulteration, within the meaning of the law of 14. May 1897, (§ 10) comprises:

1. The addition to chocolate, cacao mass, or cacao butter of foreign fat.

2. The addition to chocolate, cacao mass, or cacao powder of cacao husk, meal or other materials, except in the cases mentioned above, page 248 & 249 § 2, 1—2.

3. The addition of colouring materials to chocolate.

4. The addition to chocolate or to chocolate surrogates, of any sugar but cane sugar (beet root sugar).

§ 4.

In reference to coating materials and all manufactured articles serving the same purpose, the provisions already stated as relating to chocolate also apply.

As already pointed out (see page 248), the terms of this proposed legislative enactment naturally command approval and it would be satisfactory if the German government were to issue a „Deutsches Lebensmittelbuch",*) or something of the same kind, that would serve as an authoritative regulation of the trade in cacao preparations and as a protection of honest manufacturers against the uncertainty now attending legal proceedings. In that case, other civilized countries might be expected to adopt similar measures with as much advantage as has been effected in Belgium and Roumania.

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*) Compare remarks on this subject in the Chemiker Zeitung 1899, page 763, and 1900, page 791.

Appendix,

Containing an account of the methods of preparation and the composition of some Commercial dietetic and other Cacao preparations.

The following statements and recipes have no pretension to be complete; they are only introduced to serve as a brief summary of those commercial cacao preparations, now in commerce, which are mixtures of various kinds of substances with cacao or chocolate and are largely used for dietetic purposes. Notwithstanding its necessary incompleteness, the following account, which has been collected from various sources, will satisfy practical requirement, since the manufacturer, as well as the food chemist, frequently desires to obtain information at once, that even a complete technical library is not always able to supply. Medicinal chocolates have not been considered in the following list, since they belong to the province of pharmacy.

Acorn-cacao Michaelis' contains according to an analysis by R. Fresenius: Total nitrogen 2·29 percent, albumin 8·13 percent, sugar 25·17 percent, starch 23·39 percent, fat 14·42 percent, tannin, expressed as gallotannic acid 1·96 percent, cellulose 1·88 percent.

Acorn-cacao of Hartwig & Vogel of Dresden contains water 7·5 percent, ash 3·83 percent, fat 16·54 percent, albumin 11·25 percent, carbohydrates 38·76 percent, tannin 2·50 percent*).

Acorn-cacao of Th. Timpe of Magdeburg contains in the dry substance: albumin 13:88 percent, tannin and cacao-red 5·37 percent, carbohydrates etc. 66·41 percent, fat 10·62 percent, ash 3·73 percent.**)

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*) Hahn-Holfert, Specialitäten und Geheimmittel, page 300.

**) Pharmazeutische Zeitung 1888, page 512.

Acorn-cacao can be prepared by mixing 10 parts of pure cacao mass, 30 parts de-fatted cacao powder, 5 parts roasted barley meal, 35 parts of the meal from shelled and roasted acorns (or 10 parts of an aqueous extract of roasted acorns), 30 parts powdered sugar, and 2 parts pure calcium phosphate.

Acorn-chocolate is a mixture of 100 parts shelled and roasted acorns with 500 parts sugar and 400 parts cacao mass in addition to spices.

Acorn-malt-cacao is prepared by mixing 1 kilo of acorn malt extract (Dieterich-Helfenberg) with 6 kilos of sugar (dust), and 3 kilos de-fatted cacao.

Acorn-malt-chocolate (Dieterich) is prepared by accurately mixing 2 kilos acorn malt extract (Dieterich-Helfenberg) with 3 ½ kilos of powdered sugar and 4 ½ kilos of cacao mass.

Barley-chocolate is prepared by mixing 1 kilo of prepared barley meal,*) 4½ kilos powdered sugar and 4½ kilos cacao mass. The moulded chocolate is to be coated with varnish.

Cacao and chocolate preparations containing milk are prepared according to A. Denayer, Brussels (German patent No. 112,220, 4. February 1899) by evaporating, in the open air, a mixture of milk and sugar to the consistency of cream, and to the hot mass, de-fatted or not de-fatted cacao is added in the form of powder. The resulting mixture is spread out in thin layers and exposed to the action of a temperature of 80—100° C. in a rarefied atmosphere, then finally completely dried at a lower or ordinary temperature under the same conditions.

Cacao-egg-cream (so called African punch) is thus prepared: 10 yolks of eggs are beaten up with 300 grammes of syrup (1 part sugar to 2 parts water) and, whilst being continually whisked up, 500 grammes of cacao essence (see next paragraph) are added. The whole is to be iced before being consumed.

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*) According to Dieterich (Neues Pharmazeutisches Manual, 7. edition page 191) prepared barley meal is obtained as follow: 1 Kilo barley flour is firmly pressed into a suitable metallic (tin) vessel, so that it is about $^2/_3$ rds full and then heated on a water bath for 30 hours in all. After the lapse of 10 hours the powder is removed and ground in a mixer then again placed in the vessel and re-heated for 10 hours. After twice repeating this manipulation, about 900 grammes of a reddish mass will be obtained which is prepared barley meal.

Cacao-essence is prepared by macerating 125 grammes of de-fatted cacao, 2 grammes vanilla, 2 grammes cinnamon, 0·75 gramme cloves, 0·3 gramme mace and 0·10 gramme of ginger with 750 grammes of proof spirit and 250 grammes of water for 8 days, and then filtering into hot syrup, which is prepared with 550 grammes of sugar and 750 grammes water.

Cacao-liqueur. A well tested recipe for the preparation of this liqueur is to the following effect: De-fatted cacao 200 grammes, cinnamon powder 5 grammes, vanillin 0·2 gramme, are digested for 6 days with 1500 grammes of water and 1700 grammes of alcohol (90%) and then mixed with 2600 grammes syrup (1400 parts sugar and 1200 parts of water) and filtered.

Cacao-malt is a mixture of 200 parts de-fatted cacao, 500 parts sugar with an aqueous extract of 300 parts of kiln dried malt.

Cacaophen Sieberts (Cassel) is a mixture of cacao powder with flour, sugar and milk albumin. It shows the following numbers on analysis: fat 13·23 percent, water 7·7 percent, albumin 24·25 percent, soluble carbohydrates 17·95 percent, insoluble carbohydrates (starch) 26·66 percent, woody fibre 2·27 percent, ash 5·5 percent (calcium oxide 0·82 percent, phosphoric acid (P_2O_5) 0·54 percent).

Children's-Nährpulver (Lehmann-Berlin) is a mixture of meat extract, cacao powder, salep, sugar and prepared oyster shells.

Chocolate-cream-syrup (for aërated waters): 125 grammes of rasped chocolate, 62 grammes cacao powder and 325 grammes of water are well mixed and to this add 148 grammes infusion of quillaia (1·8). After standing some time add the contents of a pot of condensed milk with 7·5 grammes of boric acid and make up with 3·8 litres of white sugar syrup (american recipe).

Chocolat digestif (Vichy chocolate) is a mixture of chocolate with about 5 percent of sodium bicarbonate.

Chocolate-health-beer, J. Scholz (German patent No. 28 819). An extract is prepared from 10 kilos of cacao beans, which have been kiln dried at 75° C., shelled, broken in small pieces and digested for half an hour with twice their weight of distilled water at 62° C., then boiled for another half an hour and finally allowed to stand for 48 hours at a temperature of 75° C., with an addition of a solution of 10 kilos of sugar in distilled water, then once more boiled until one half of the water, originally added, has been evaporated. It is filtered, in as warm a condition as possible, in order to separate pieces of cacao and fat, and the extract is ready for use. The brewing process is similar to that of brewing Bavarian beer. After the finished wort obtained in that process has been boiled for 3 hours, 100 litres are taken, for which 35 kilos of pale kiln dried barely meal have been used, and to this are added 200 grammes of the best Bavarian hops and 12 kilos of cacao extract. The whole is once more boiled and the subsequent operation then carried out as usual. The fermentation (at 7·5° C.) occupies 7—8 days and the storage in the fining vats 3—4 weeks.

Chocolat rétablière, a Vienna speciality, contains reduced metallic iron, dried-meat, pea and wheat flour, sugar and cacao in uncertain proportions.

Chocolate-syrup (for soda and seltzer water). 250 grammes of de-fatted cacao powder are rubbed down with 2½ litres of boiling water in a porcelain basin on a steam bath, until it is in the condition of an uniformly thick mass and then 1 kilo pot of condensed milk and 2·5 kilos of powdered sugar are added, and when the sugar is dissolved the vessel is cooled. After cooling, the fatty particles on the surface are carefully removed, and then 30 grammes of commercial vanilla extract and 30 grammes of mucilage (from gummi arabicum) are added, and the whole filtered through a stout cotton cloth (american recipe).

Chocolate-tincture (cacao-tincture) is prepared by macerating 1½ kilos of de-fatted cacao powder with 10 kilos of dilute alcohol for 8 days and then filtering.

Corn-cacao contains according to Nothnagel*): water

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*) Apotheker-Zeitung 1900, page 181.

6·10 percent, fat 16·96 percent, albuminoids 19·81 percent, theobromine 0·68 percent, fibre 3·30 percent, non-nitrogenous extractives 48·69 percent, ash 4·46 percent. The preparation under the microscope is shown to contain, in addition to the constituents of cacao, a large amount of oat starch, and it may be regarded as corresponding to a mixture of equal parts of de-fatted cacao and oat meal, based on the above analysis and König's mean value.

Diabetic chocolate has the following composition.*) Nitrogenous substance 10·07 percent, fat 25·47 percent, levulose 19·38 percent, starch and cellulose 25·19 percent, besides non nitrogenous substances 14·54 percent, saccharin 0·5 percent, mineral constituents 2·15 percent.

In this formula there is a disproportionately high percentage of starch and cellulose and, in that respect, the composition appears to be irrational, since the introduction of carbohydrates into food for diabetics should be avoided as much as possible. A more rational preparation would be a simple mixture of:

	50	parts	levulose,
	50	,,	cacao mass.
and	0·25	,,	vanillin.

Aufrecht's recipe for **diabetic cacao** is as follows:

cacao powder	500	grammes
levulose	200	,,
wheat flour	280	,,
saccharin	5	,,
aromatic substances	15	,,

In this recipe, also, the substitution of levulose for wheat meal is to be recommended.

Diabetic cacao can be prepared according to J. Apt of Berlin by the following patented process (German patent No. 116,173, 30. 1. 1900). The starch is first gelatinized by long boiling of the coarsely powdered cacao, the mass then dried in a vacuum and heated, or roasted at 130 to 140° C. in order to caramelize the gelatinized starch (!). Before being boiled, it is recommended to de-fat the cacao (with petroleum ether, for example!). Instead of caramelising the gelatinized starch by heat direct, it can be first converted into sugar by means of acid, then heated to caramelisation and as much cacao fat added as may be desirable. In order to increase its capability of emulsifying, dried albumin is to be added.*)

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*) Compare Aufrecht, Pharm. Zeitung 1900, page 558.

Dictamnia of Groult and Boutron-Russel is composed of cacao, prepared wheat flour, starch, sugar and vanilla.

v. Donat's albumin chocolate (German patent No. 82434) is prepared by mixing dried albumin in powder or in pieces with chocolate or cacao mass, damped with a liquid medium, which does not dissolve albumin, such as benzol, petroleum ether, ether, acetone, methyl or ethyl alcohol. The mass is further treated in the mixer and finally after being completely mixed, the added liquid is allowed to evaporate.

Eucasin-chocolate and cacao are preparations containing 20 percent of eucasin (ammonium caseinate). Eucasin is preparated by Majert & Ebers of Grünau-Berlin.

Galactogen-Cacao, Thiele & Holzhause-Barleben near Magdeburg, contains 30—32 percent of galactogen, an easily soluble and natural preparation of milk albumin, which is prepared from skimmed milk and contains 70 percent albumin, 3·5—4 percent fat as well as 1·5—1·79 percent phosphoric acid. Galactogen-amylaceous cacao, contains wheaten flour in addition to 20—22 percent galactogen. Galactogen-Speise-Schokolade (eating chocolate) with 30 percent galactogen and Galactogen-Koch-Schokolade (cooking chocolate) are also prepared.

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*) The absurdity of this process is too evident to need remark; would it not have been better, if the process had not had the sanction of the patent mark? The treatment, which the cacao here undergoes, is so barbarous, that the product must always be spoiled. The only point attained is the complete gelatinization of the starch, which by further heating is to some extent converted into dextrin. Caramelizing cannot and will not take place by heating gelatinized starch in mixtures with a dry substance. as it occurs in Cacao. But in addition. the claim is weak that cacao so mistreated would be especially suitable for diabetics, since soluble cacao serves that purpose a great deal better. The addition of albumin is not at all new, for mixtures of albumin and cacao have existed for a very long time. (The Author).

Plasmon and lacto-egg-powder are similar products to galactogen, and are met with in commerce combined with cacao mass and chocolate (see plasmon cacao).

Gaugau is a children's tea (Vienna) and consists of cacao husk.

Hansa-Saccharin-Cacao is de-fatted cacao, which contains about 0:5 percent saccharin (270 times as sweet as sugar), 30 percent fat and 20 percent albuminoids (Hahn-Holfert).

Hardidalik, an asiatic chocolate, is composed according to Chevallier of 42 parts cacao, 180 parts sugar, 112 parts starch flour, 64 parts rice flour and 3 parts vanilla.

Hensel's Nähr-Cacao, is a mixture of de-fatted cacao-powder with various inorganic salts, such as calcium carbonate and phosphate; the ash of this preparation was found to contain a larger amount of sulphuric acid, soda and iron, than is present in normal cacao. The fat amounted to only 5·3 percent.

Homoeopathic-Chocolate of E. Kreplin, Lehrte, consists of 35 percent pure cacao mass, 20 percent slightly roasted wheat flour and 45 percent sugar (Hager).

Husson's Mixture contains the following materials: Arrow root 500, oat meal 500, powdered sugar 500, powdered sago 400, cacao 50, calcium phosphate 50, vanilla 1.

Hygiama resembles cacao in appearance and flavour and was introduced into commerce by Dr. Theinhardt's Nahrungsmittel-Gesellschaft of Cannstatt (Wurtemberg). It is prepared from condensed milk with the addition of a specially prepared cereal and de-fatted cacao. It contains 22·8 percent albumin, 6·6 percent fat, 52·8 percent soluble carbohydrates, 10·5 percent insoluble carbohydrates, 2·5 percent food salts, 4 percent moisture.

Iceland-moss-chocolate contains 10 percent iceland moss gelatine.

Kaïffa (Fécule orientale) is a mixture of 500 parts cacao mass, 1250 parts rice flour, 250 parts groats, 250 parts Iceland moss gelatine, 2300 parts starch, 750 parts salep, 1000 parts sago, 6000 parts sugar and 50 parts vanilla.

Kola-Chocolate is prepared by mixing 400 grammes of cacao mass, 450 grammes sugar, 100 grammes kola seeds in powder, 40 grammes cacao fat and 5 grammes vanillin sugar (3 percent).

Kraft-Chocolate (Mering's). This is a trade preparation in which cacao butter is made into an emulsion, probably by means of oleic acid, and is thus rendered more digestible. Kraft-chocolate should contain 21 percent of easily digestible fat.

Lipanin-Chocolate contains 42·38 percent fat, albumin 8·07 percent, starch 2·7 percent, sugar 31·44 percent, in addition to non-nitrogenous substances 18·19 percent, ash 0·68 percent, as well as some vanillin and peruvian balsam (Aufrecht).

Malt-cacao according to Franz Abels (German patent No. 96,318, 9. May 1896) is prepared in the following manner: The cacao mass after being mixed with malt meal is defatted by strong hydraulic pressure in order that the malt may be permeated with cacao fat. It is then pulverized.

Malt-cacao-syrup or **malted chocolate** is prepared by mix ing 240 grammes malt extract and 24 ccm vanilla extract with about 950 grammes of chocolate syrup. Vanillin or essence of cinnamon may be used instead of vanilla extract. This preparation serves for the making of american effervescing lemonade.

Malt-chocolate. 2 kilos of finely powdered malt and 3½ kilos powdered sugar, both well dried, are mixed in small quantities with 4½ kilos cacao mass in the mixing machine. The tablets are to be coated with varnish to preserve them. (E. Dieterich.)

Malt-extract-chocolate. 4½ kilos of the finely rubbed down cacao mass, contained in the mixing machine, are intimately mixed with 1 kilo dried malt extract and 4½ kilos powdered sugar. The finished tablets are to be coated with varnish. (E. Dieterich.)

Malto-leguminose-cacao gives the following numbers on analysis: water 7·38 percent, nitrogenous substance 19·71 percent (18·26 percent digestible), theobromine 0·71 percent, maltose 1·88 percent, dextrin etc. 3·53 percent, starch 27·82 percent, besides non-nitrogenous extractives 13·8 percent, fibre 2·36 percent, ash 4·94 percent (potash 1·74 percent, phosphoric acid 1·51 percent).

Meat-extract-chocolate is prepared by placing 500 grammes of meat extract (Cibil's or Liebig's) in a porcelain basin and evaporating down as much as possible on the water bath: 4·7 kilos of powdered sugar are then added and the whole rubbed down with the pestle until the extract is homogeneous. 5 kilos of cacao mass are added and the chocolate finished in the mixer. The moulded tablets must be coated with varnish (Dieterich).

Milk-cacao is prepared with 1 kilo of condensed milk (prepared in a vacuum with the addition of 10 percent of milk sugar *) 500 grammes milk sugar and sufficient powdered arrowroot to produce a paste, which is then rolled out, broken up and lightly baked. This milk biscuit is ground and passed through a fine hair sieve. 750 grammes of the pulverized milk biscuit are then carefully mixed with 250 grammes of de-fatted cacao and 10 grammes of an aromatic mixture and the preparation finally preserved in metallic boxes.

A more bitter-milk-cacao can also be prepared with 30 kilos cacao powder and 50 kilos pure milk powder. This proportion may also be varied, so that more milk powder may be used, as for example 40 kilos cacao powder and 60 kilos pure milk powder or 30 kilos cacao powder and 70 kilos pure milk powder.

A sweet-milk-cacao can be obtained thus:

a) 30 kilos cacao powder,
20 „ powdered sugar,
50 „ pure milk powder

b) 20 kilos cacao powder
30 „ powdered sugar,
50 „ pure milk powder,

c) 15 kilos cacao powder,
35 „ powdered sugar,
50 „ pure milk powder.

Milk-chocolate is prepared with 28 kilos cacao mass, 36 kilos powdered cane sugar, 24 kilos milk powder and 12 kilos cacao butter. The material is very finely rolled at

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*) Or pure milk powder from the Holstein Dairy-works or the Dresden Dairy of Gebr. Pfund, Dresden-Neustadt. The cacao milk powder from the preserved milk factory of Emil Passberg, 33. Brückenallee, Berlin N.W. gave on analysis, fat 24·2 percent, nitrogenous substance 23·4 percent, milk sugar 29·2 percent, non-nitrogenous substance (starch) 8·8 percent and mineral constituents 6 percent.

60—70° C. in Lehmann's grinding machine described on page 140, and the finished mass not allowed to remain in the hot closet, but almost immediately moulded and packed. The mild kinds of cacao (Ariba, Caracas, Ceylon, Java) are the most suitable for making milk chocolate. In the manufacture of pure milk cacao, the cacao powder is worked up for some time in the warmed mixing machine, the sugar and the milk powder being added successively. Cacao preparations, which are only used as beverages with water, should have at least two parts of pure milk powder to one part of cacao powder in order to obtain a suitable preparation.

Mutase-cacao with 20 percent mutase: contains water 5·66 percent, fat 25·24 percent*), albumin 28·31 percent, fibre 3·81 percent, theobromine 1·67 percent, non-nitrogenous extractives 30·72 percent, ash 6·26 percent.

Mutase-chocolate (with 20 percent mutase) contains 16·17 percent of albumin. Mutase is an albumin preparation obtained, without the use of chemical reagents, from nutritive plants, also containing the nutritive salts of the plant (10 percent). Mutase contains 60 percent of albumin.

Nährsalz-cacao (Lahmann) Food-salt cacao. It contains water 8 percent, nitrogenous substance 17·5 percent, theobromine 1·78 percent, fat 28·26 percent, starch 11·09 percent, non-nitrogenous extractives 26·24 percent, fibre 4·21 percent, ash 4·7 percent (potash 1,66 percent, phosphoric acid 1·56 percent). Nährsalz-cacao or chocolate is prepared by mixing a vegetable extract (from leguminous plants) with cacao or chocolate. The analysis of Lahmann's Nährsalz-chocolate gave the following numbers: fat 24·5 percent, ash 1·36 percent, water 1·08 percent, albumin 6·25 percent, phosphoric acid (P_2O_5) 0·44 percent.

Nähr- und Heilpulver. (Food and health-powder) of **Dr. Koeben** contains sugar, cacao, pollards and acorn coffee. (Hager's Handbuch der Pharmaceutischen Praxis.).

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*) All cacao preparations, to which albumin is added, require a large amount of cacao butter as the albuminoids largely absorb the fat.

Natur-cacao and natur-chocolate (natural cacao etc.) Spindler, Stuttgart (German patent No. 47,226) are obtained by mixing cacao mass with hot honey. This effects a de-fatting of the cacao mass by spontaneous separation of the fat. The de-fatting can be suitably carried further by pressing. Instead of using honey, the de-fatting can be carried out with syrups, malt extract, condensed milk, fruit juices or plant mucilage (extracts from pulse).*)

Nuco-cacao is a mixture of cacao with "nuco", which is a highly praised preparation of albumin. The analysis of nuco cacao gave ash 4·06 percent, moisture 6 percent, fat 15·23 percent, albumin 47 percent, the iodine value of the fat is = 86. The fragments of tissue under the microscope appear completely analogous to that of earth nut (arachis hypogaea). Nuco-cacao is consequently nothing more than a mixture of de-fatted cacao with de-fatted earth nut (earth nut cake).

Oat-cacao, Hallenser (half and half) contains 6·5 percent moisture, 4·1 percent mineral constituents, 89·4 percent organic substances (containing 4·3 percent nitrogenous matter) digestible albumin 14·7 percent, fat 17·2 percent, theöbromine 0·77 percent, starch and other non-nitrogenous extractives 48·93 percent, cellulose 3·5 percent. This is evidently a mixture of equal parts of oat meal and cacao powder as the name implies.

Oat-cacao Kasseler (Hansen & Co.) is prepared according to the German patent No. 93500, 28. June 1896, by mixing oat meal with cacao. This mixture is moulded, pressed and, after being wrapped in perforated tin foil, de-fatted by ether. It contains 7·2 percent moisture, 3·5 percent mineral substances, 89·3 percent organic substances, which are composed of nitrogenous substance 3·9 percent, digestible albumin 18·8 percent, fat 18·3 percent, theobromine 0·46 percent, starch and other non-nitrogenous extractives 44·94 percent, cellulose 2·9 percent.**) It is likewise a mixture of 50 percent oat meat with 50 percent cacao.

---

*) The composition of the preparation must be stated on the wrapper as such terms as "Natur-cacao" and "Natur-chocolate" are liable to lead the purchaser astray. (The Author.)

**) Alfr. Beddies, Ueber Kakaoernährung, Berlin 1897.

Oat-cacao can be simply prepared by mixing cacao powder with an equal part of prepared oat meal, such as is produced by Hohenlohe's Präservefabrik, by Knorr of Heilbronn, by Raffauf of Coblenz and by the Quaker Oats Company. In order to cover the taste of the oat meal 1—2 percent of sodium chloride is to be added.

J. Berlit, German patent No. 72449, describes the following method for the preparation of **oat-cacao**. Oats are cleaned, bruised, slightly roasted and ground. The powder is wetted and by means of a kneading machine worked up to a paste which is dried in a vacuum, finally ground and mixed with de-fatted cacao in the required proportions.

Palamoud des Turcs consists of cacao mass, rice-meal, starch and sandal wood.

Peptone-cacao contains: water 4·08 percent, nitrogenous substance 20·56 percent, albumose 8·25 percent, peptone 4·41 percent, theobromine 1·03 percent, sugar 49·51 percent, besides non-nitrogenous constituents 9·37 percent, woody fibre 1·43 percent, mineral substance 4·17 percent (potash 1·97 percent, phosphoric acid 1·21 percent).

Peptone-powder-cacao (20 percent) is prepared by mixing 20 parts of Koch's meat peptone in the form of extract with 50 parts of sugar and 40 parts cacao powder.

Peptone-chocolate contains 10 percent of dry peptone.

Plasmon-chocolate and cacao contains 20 percent plasmon*) (Siebold).

Racahout des Arabes see page 85.

Saccharin-cacao gave the following results on analysis: water 7·26 percent, nitrogenous substance 20·5 percent, theobromine 2·09 percent, fat 32·25 percent, saccharin 0·4 percent, starch 13·02 percent, non-nitrogenous extractives 13·51 percent, woody fibre 5·27 percent, ash 5·93 percent, (potash 2·16 percent, phosphoric acid 1·69 percent). See also Hansa-Saccharin-cacao on page 256.

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*) Plasmon is an albuminoid preparation from milk, to which a little sodium bicarbonate is added to effect complete solution.

Somatose-cacao with sugar and somatose-chocolate contains about 10 percent somatose;*) the first preparation contains 20·71 percent total nitrogenous substance, and the latter 10·24 percent, of which about $^1/_3$ consists of soluble nitrogenous compounds. (Mansfeld.) The first preparation could be readily prepared by mixing 10 parts of somatose (Farbwerke Bayer & Cie., Elberfeld) with 50 parts of sugar and 40 parts of cacao powder.

Theobromade (theobromine) is a dry extract from cacao husks.

Dr. Thesen's Proviant comes into commerce in the form of chocolate and is chocolate with an addition of albumin. Its analysis gave the following results: Albumin 20:5 percent, theobromine 0·56 percent, fat 39·79 percent, carbohydrates a) (soluble) 26·95 percent, b) (insoluble) 5·66 percent, ash 2·25 percent, water 1·57 percent. A similar product to Thesen's Proviant results from mixing: albumin 12·5 parts, fat (cacao butter) 10 parts, fat (cocoa nut butter) 7·5 parts, sugar 25 parts, cacao 45 parts.

Tropon-cacao is a varying mixture of tropon, 15—33$^1/_3$ percent, with cacao powder. A tropon cacao containing 20 percent of tropon gave on analysis: water 5·75 percent, albumin 38·49 percent, fat 27·77 percent, fibre 3·76 percent, ash 4·51 percent, theobromine 1·6 percent, extractives 22·78 percent.

Tropon-chocolate is a chocolate containing 25 percent tropon.**)

Tropon-Oat-cacao contains 20 percent tropon, 30 percent oat meal and 50 percent cacao powder.

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*) Somatose is a nutritive preparation made from meat and contains the nitrogenous constituents of the muscle flesh exclusively in the form of an easily soluble albumose.

**) Tropon is a mixture of 2 parts flesh albumin (from muscle flesh and fish) and one part plant albumin.

Wacaca des Indes consists of 60 parts cacao powder, 165 parts sugar, 8 parts cinnamon, 2 parts vanilla and some tincture of ambergris.

White chocolate contains sugar 3000 parts, rice meal 860 parts, potato flour 250 parts, cacao butter 250 parts, gum arabic 125 parts and vanilla tincture 15 parts.*)

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*) The preparation must also bear on the wrapper a statement of its composition in order not to mislead the purchaser.

Index to the literature.

In the following list are specified in chronological order only those works and memoirs which refer to the culture of cacao and the manufacture of cacao preparations. The remaining literature on the subject, so far as it refers to the scientific side, has already been mentioned in the form of footnotes.

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Index.

Page:

Accumulators . . . 185
Acid fuchsin . . . 96
„ yellow R . . . 97
„ value of cacao fat . . . 42
Acrolein formed in over roasting . . . 105
Acorn cacao, Hartwig & Vogel's . . . 250
„ „ , Th. Timpe's . . . 250
„ Chocolate . . . 251
„ Malt Cacao, Dieterich's . . . 251
„ „ Chocolate, Dieterich's . . . 251
Adulteration of cacao goods and its detection . . . 233
African cacao . . . 25
After fermentation of the beans . . . 101
Air extracting machine, old form . . . 145
„ „ „ , with automatic feeder . . . 146
„ „ „ , „ „ „ and dividing apparatus . . . 146
Air extraction from chocolate . . . 144
Albumin, amount in the cacao bean . . . 54
„ , artificial digestion . . . 57
„ , chemical determination . . . 56
„ , Chocolate, v. Donat's . . . 255
„ , constitution . . . 56
„ , consumption in the human organism . . . 58
„ , decomposition of . . . 55
„ , soluble, in cacao bean . . . 55
„ , the addition of, to cacao goods . . . 259
„ , true, in cacao . . . 55
Albuminate in cacao goods, determination of . . . 228
Aleuron granules . . . 54
Alizarin blue . . . 97
Alkali added to cacao, determination of . . . 220, 221
„ in cacao powder, normal amount . . . 221
„ in the shelled, roasted beans . . . 221
„ „ „ unshelled, „ „ . . . 220
Alkalies fixed . . . 180
„ for "soluble" cacao, solution of . . . 196
Alkaline albuminate . . . 60
Amazon cacao . . . 22
Ammonia liquor, for rendering "soluble" . . . 196
„ in cacao, determination of . . . 221
Ammonium carbonate for rendering "soluble" . . . 196
Analytical results, calculation of . . . 235
Aniline blue . . . 97
„ colours, soluble in fat . . . 97
American cacao . . . 18
Arctic Patent dry cold air machines . . . 164
Ariba-Guayaquil cacao, characteristics of . . . 20
Arrow root . . . 84
Ash in cacao preparations, determination of . . . 219
„ in raw cacao, amount of . . . 64
„ „ „ „ beans, analyses of . . . 65

Page:
Ash of cacao husks . . . 220
Asiatic cacao . . . 24
Association formulæ . . . 231. 248
Austria, trade in cacao goods . . . 242
Austrian codex alimentarius . . . 242

Bahia cacao, characteristics . . . 22
Ball machines . . . 80
Barley chocolate . . . 251
„ meal prepared . . . 251
Barium sulphate in chocolate cigars . . . 233
Battery roller machines . . . 134
Baudouin's test . . . 44
Bean meal . . . 84
„ „ roasted . . . 85
Belgian decree on the trade in cacao goods . . . 236
Benzin motor . . . 211
Benzoyl-sulphonimide . . . 81
Berbice cacao, characteristics . . . 21
Björklund's test . . . 40
Botanical description of the cacao bean . . . 7
Bordeaux red . . . 96
Börnstein's test . . . 82
Brazilian beans . . . 21
„ cacao . . . 22
Brick dust in cacao preparations . . . 233

Cacao blanco . . . 14
„ beans, chemical constituents of . . . 32. 33. 34
„ „ , various mixtures of . . . 118
„ butter, definition of . . . 232
„ „ filter, V. Haenig & Co.'s . . . 184
„ „ , production and commercial value . . . 46
„ „ , rancidity of . . . 37
„ culture . . . 4
„ egg-cream . . . 251
„ essence . . . 252
„ fat, determination of melting point . . . 38
„ „ , digestibility of . . . 44
„ „ , expression of, history . . . 182
„ „ , filtration of . . . 184
„ „ , hydraulic presses . . . 182
„ „ , melting point . . . 38. 39
„ „ , methods of determination . . . 36
„ „ , specific gravity . . . 38
„ „ , use of . . . 44
„ flowers . . . 7
„ fruit . . . 8
„ glucoside . . . 46
„ „ , decomposition of . . . 46
„ goods, valuation of . . . 232
„ , hot vessels for . . . 123
„ husks, analyses . . . 67
„ „ as an improvement to coffee . . . 72
„ „ „ a medicinal agent . . . 72
„ „ „ fodder . . . 73
„ „ „ „ , the value of . . . 73
„ „ „ manure . . . 73
„ „ ash constituents . . . 68
„ „ briquettes . . . 73
„ „ , colouring matter from . . . 72

Page:
Cacao husks, determination in cacao goods 225
„ „ , „ according to Filsinger 225
„ „ in cacao powder 229
„ „ , microscopy of 70, 71
„ „ , separation from the kernels 110, 111
„ shells or husks 67
„ husks, the use of 71, 72
„ importation into France, value of 30
„ „ „ U. S. America, value of 30
„ , increased consumption of 31
„ liqueur 252
„ malt 257
„ mass, mixed with sugar and spices 123
„ „ , definiton of 232
„ mills, simple 119
„ „ , working capacity of 122
„ „ , advantage of 120
„ oidium, Royer 207
„ pigment 46
„ plantations 5
„ powder, definition 232
„ „ , detection of saccharin in 82
„ „ factory, installation of 217
„ „ , in general consumption, analyses of 203
„ „ , physiological assimilation of 58, 204
„ „ preparation 188
„ „ preparations containing milk 258, 259
„ „ preparation of soluble 178
„ red 46
„ „ crude 47
„ „ , formation of 46
„ , solubility of 178
„ , stains on linen, removal of 48
„ tree, care of 6
„ wood bark 12
Cacaolol 234
Cacaonin 46
Cacaophen, Siebert's 252
Cacogna 178
Caffeine in cacao beans, amount of 52
„ determination in cacao goods 52
Cake chocolate 147
Cameroon cacao, characteristics 25
Cancer of cacao bean 5
Caracas beans 19
„ cacao, characteristics 19
Carob beans in cacao 230
Cellulose in cacao 62
Centrifugal roasting apparatus, Salamon's 108
„ sifting machine 77, 188
Ceylon cacao 1, 2, 24
„ „ characteristics 24
Chestnut meal 84
Childrens Nährpulver, Lehmann's 252
Chlorophyll 97
Chocolate, cheaper kinds of 138
„ cigars 148
„ creams, preparation of 139
„ -cream syrup 252
„ , definition of 231
„ digestif 252

Page:

Chocolate eggs 149
„ factory, installation of 215
„ filled with cream 150
„ health beer 253
„ lac 95, 206
„ lozenges 164
„ „ , Reiche's machine for 165
„ making history of 98
„ moulding 147
„ pastilles 164
Chocolat rétablière 253
Chocolate rings 172
„ surrogate, definition of 232
„ syrup 253
„ tincture 253
„ varnish 95
Chna Cacao 19
Choroni cacao 19
Cigar moulds 148
Cinnameïn 95
Cinnamon 91
„ oil 91, 93
Clay in cacao goods 233
Cleansing the beans 99
„ „ „ in casks 101
„ „ „ „ cylindrical screens 101
Cloves 92
Coal in cacao preparations 233
„ tar colours, permitted 96
Cocoa nut oil in cacao fat 43, 233
Codex alimentarius austriacus 242
Coffie-mama 2
Cole J. & W., cooling arrangement 163
Colour of the cacao kernels 14
Colouring materials allowed 96
Commercial kinds of cacao beans 17
"Conches" 140, 141
Confiture lac 95
Consumption, relative, of tea, coffee and cacao 31
Cooling and exhausting arrangements 109
Cooling cellar 157
„ the chocolate 156
„ „ expressed cacao 188
„ „ roasted beans 109
Copper in the ash of cacao 66
Coral tree 2
Coriander oil 93
Corn cacao 253
Cotton seed oil in cacao fat 44, 45, 233
Couverture, composition 169
„ frames 171
„ mass, mixing machine 169, 170
Crude fibre determination, Koenig-Filsinger's method 62, 63
„ „ „ , Weenders process 62
„ „ in cacao 62
„ „ „ „ goods, determination of 225
„ „ „ „ , amount of 63
„ „ „ defatted cacao powder, amount of 202, 205
Crumb chocolate 149
Crushers for the cacao press cakes 191
Crushing and cleansing machines, Lehmann's 110

Page:
Crushing and cleansing machines, Lehmann's, working power of 116
„ the roasted beans . . . 109
Crystal sugar . . . 76
Crystallose . . . 81
Cuba cacao, characteristics . . . 22
Cultivation of cacao in Ceylon . . . 1, 2
Cumarin, detection of in vanillin . . . 89
Cylinder rolling machines . . . 119, 130

Declaration of composition required . . . 248, 260, 263
Definition of cacao preparations . . . 231
Dextrin . . . 83
„ in cacao goods . . . 223
Diabetic cacao . . . 254
„ „ Apt's . . . 254, 255
„ chocolate . . . 254
Dictamnia . . . 255
Dika fat . . . 43
Diesel motor . . . 211
Disintegrators . . . 80
Diureïds . . . 48
Diuretin . . . 50
Division of the chocolate . . . 144
Double hoists . . . 155, 156
Dawson gas . . . 212
Dulcin . . . 81
Dusting machine for fondants . . . 168, 169
Dust purifying machine, Lehmann's . . . 115
Dutch cacao, properties of . . . 204
„ method, the advantages of the . . . 199

Earth nut cake in cacao . . . 230
„ „ in cacao . . . 230
„ „ oil in cacao fat . . . 44, 233
Ecuador cacao . . . 18
Edge runners . . . 76, 77
Electro-motors . . . 211, 213
Enemies of the cacao . . . 5, 99, 207
Eosin . . . 96
Erythrosin . . . 96
Esmeralda cacao, characteristics . . . 18
Essequibo „ „ . . . 21
Ethereal oils, the employment of . . . 93
Etymology of the name chocolate . . . 3
„ „ „ „ cacao . . . 2
Eucasin chocolate and cacao . . . 255
Expressed cacao . . . 187
Experimental tests with cacao . . . 138
Extracted fat . . . 37

Fat, acid value . . . 42
Fatty acid crystals in the cacao tissue . . . 15, 59
„ acids in cacao solid . . . 40
„ „ in cacao volatile . . . 40
Fat amount of, in expressed cacao . . . 187, 188
„ Björklund's test . . . 39
„ chemistry of the . . . 37
„ Iodine value . . . 41
„ determination in cacao goods . . . 36, 221
„ „ , agitation method . . . 222, 223
„ „ . . . 36
„ and fat acid detection, microscopically . . . 15

Page:
Fat excess in cacao preparations 233
„ , expression of the 36, 182
„ , foreign, in cacao preparations 43, 233
„ in the husks 36, 42
„ , melting point 38, 39
„ , methods of investigation 41
„ of the raw and roasted beans, properties of 36, 37
„ Reichert-Meissl value 42
„ refractometer test 42
„ , saponification value 41
Fecule orientale 256
Fermentation of the beans 9, 10, 11, 12
„ „ in Jamaica 9
Fernando Po cacao 26
Ferruginous loam 14
Figured chocolate 149
Filtration of cacao butter 184
Filsinger's test 40
Flake chocolate 148
Flavouring cacao powder 200
France, cacao imports 27
Fondants, machine for making 167
„ preparation 167
Foreign starch in cacao, microscopical detection 228
„ „ „ „ chemical detection 61, 64, 229, 230
Form of chocolate 147
Fruit bark of the cacao 12
Fuchsin „ „ 96

Gaedke's "soluble" cacao 198
Galactogen cacao 255
Gas motor 211
„ power motor 212
Gathering the cacao fruit 8
Gaugau 256
Gelatin in cacao goods 219
German legal enactments and their value 247
„ exports of cacao products 29
„ Lebensmittelbuch 249
„ trade in cacao goods 247
Geographical distribution of the cacao tree 1
Globulin 55
Globoid in cacao 54
„ in the ash of cacao 52, 66
Glucin 81
Glucoside 46
Granite for rolling machines 130
Great Britain's imports, the value of 30
„ „ consumption of cacao products 29
Grinding and sifting apparatus combined, Lehmann's 78
Group workings, the system of 213, 214
„ „ , „ advantages of 214
Guiana beans 13
Guayaquil cacao 20
Guatemala cacao 24
Guiria 19
Gum benzoin 95
„ disease 5

Haiti cacao, characteristics 23
Hansa-saccharin cacao 256
Hardidalik 256

Page:
Hazel nut oil in cacao fat . . . 44
„ „ pulp in cacao . . . 230, 233
Hensel's Nährcacao . . . 256
History of the cacao . . . 2, 3, 4
Hoisting machines . . . 208
Holland's consumption of cacao goods . . . 29
Homoeopathic chocolate . . . 265
Hot closets . . . 142
Hot air motor . . . 211
Houten, van . . . 178
Husks added to the beans, detection of . . . 69
„ in unshelled beans, amount of . . . 182, 183
Hygiama . . . 256

Java cacao, characteristics . . . 25
Iceland moss chocolate . . . 256
Index to the literature . . . 264
Import of cacao into Germany . . . 28
„ „ „ preparations into Germany . . . 28
Ingredients used in the manufacture of chocolate . . . 75
„ forbidden in cacao goods . . . 249
„ allowed „ „ „ . . . 248, 249
Indulin . . . 97
Investigation of cacao goods, chemical . . . 281
Iodine value of the cacao fat . . . 41

Kaïffa . . . 256
Kakaoline . . . 43
Kola-chocolate . . . 256
„ red . . . 46
Kneading and mixing machines, Werner & Pfleiderer's . . . 194
„ machine, situation of the . . . 197
Kraft chocolate, Mering's . . . 257
Krüllots . . . 6
Kunerol . . . 43

Lactine . . . 43
Laureol . . . 43
La Guayra . . . 19
Levigation of chocolate . . . 130
„ method for determination of cacao husks, Filsinger's . . . 225
„ , the principles of . . . 130
Lipanin chocolate . . . 257
Lifts . . . 208, 209
Lobeck's "solubility"-method . . . 198

Machala-Guayaquil cacao, characteristics . . . 20
Mace . . . 92
Madre del cacao . . . 2
Magnesium carbonate for rendering "soluble" . . . 179, 181
Malachite green . . . 97
Malt cacao . . . 257
„ „ syrup . . . 257
Malted chocolate . . . 257
Malt-extract-chocolate . . . 257
Malto-Leguminose cacao . . . 257
Manufacture of cacao preparations . . . 98
Mannheim cocoa nut butter . . . 43
Maracaïbo cacao, characteristics . . . 21
Margarine in cacao fat . . . 45
Martinique cacao . . . 24

Page:
Martol 72
Meal, as an adulteration 233, 248, 249
Meat extract chocolate 258
Melangeur with three runners 129
„ „ fixed bed stone 129
„ „ dish shaped bottom 144
„ „ rotating bed stone 127
Metallic wrappers 206
Methyl violet 97
Microscopic investigation of the kernels, methods of 14, 15, 228
„ -botanical investigation 228
„ investigation of the residue in the levigation test 226
Milk cacao 258
„ „, a more bitter kind of 258
„ chocolate 258
„ „ fat, Reichert-Meissl value 42
Mills for preliminary grinding 119
Mitscherlich's particles 15
Mixtures for chocolate, relative proportions of 137, 138
Moisture in cacao goods, determination of 218
Moths in the cacao store rooms 100
Motors 210
Mould in chocolate, formation of 207
„ in cacao powder, growth of 197
Moser & Co's, "solubility" process 194
Murexide reaction 53
Mutase cacao and chocolate 259

Nähr- and Heilpulver, Koeben's 259
Nähr-Cacao, Hensel's 256
Nähr Salz cacao and chocolate, Lahmann's 259
Natur cacao and chocolate 260
Native Ceylon cacao 24
Naphtol yellow 97
Napolitaines 148
Nine roller machine, Lehmann's 135
Nucoabutter 43
Nuco-cacao 260
Nutmeg 92

Oat cacao 261
„ „ Berlit's 261
„ „ Hallenser 260
„ „ Kasseler 260
Observation media for microscopical investigation of cacao 16
Ochre yellow in cacao preparations 233
Ocunnare 19
Official enactments respecting the trade in cacao preparations 231, 248
„ „ „ „ „ „ „ „, Roumanian decree 238
„ „ „ „ „ „ „ „, Belgian decree 236
Orange I 97

Packing cacao powder 201
„ „ preparations 231
„ „ „, chemical criticism of 201
Packet filling machine, Seelig's 234
Palm nut oil in cacao fat 43
Palamoud des Turcs 261
Palmin 43
Paraffin in cacao fat 43, 45
Para cacao 22
Pastille machine, A. Reiche's 165

Page:
Paternosters 208
Peptone cacao and chocolate 261
Peptone powder cacao 261
Peru balsam 95
Phloxin 96
Petroleum motor 211
Pigment cells in cacao 15
Piperonal in vanilla 86
Plant acids 64
"Plant butter" 43
Plasmon cacao and chocolate 261
Pompona vanilla 87
Ponceau red 96
Port au Prince cacao 23
Potato starch 83
Potash in cacao powder, amount of 220, 221
Potassium carbonate for rendering "soluble" 179, 181
Potash, amount of, in certain articles of food 204
Powdering cacao 188
„ expressed cacao 188
Pralinés, preparation of 167
„ , Lehmann's dipping machine 173, 175, 176
„ , Reiche's coating apparatus 170
„ , dipping of 169
Presses to exert great pressure 188
„ , hydraulic, Lehmann's 182
„ with an accumulator 185, 186, 187
Preliminary mixing machine, Lehmann's 124
„ warming of the chocolate mass 125
Principe cacao 26
Produce of the cacao fruit 5
Protein 54
Puerto Cabello cacao, characteristics 19
Pulverizer, Lehmann's 189, 191, 192, 193

Quadruple rubbing machine, Lehmann's 139, 140

Racahout des Arabes 85
Radicles removal of, Lehmann's machine 113
Rancidity of cacao fat 37
Raw shelled beans, analyses of 32, 33
Red (fast) 96
Red ferric oxide in cacao preparations 233
Refractometric investigation of cacao butter 42
Refrigeration, artificial, in a chocolate factory 158
„ , „ , French system 161
„ , „ , Douane's system 163
„ „ , T. & W. Cole's system 163
„ , artificial, Wegelin & Hübner's system 159, 160, 161
„ , working capacity of Wegelin & Hübner's system 162
Reichert-Meissl value of cacao fat 42
Removal of the alkaline solvent 195
Rice starch 83
Rio Chico 19
„ Caribe 19
Roasted shelled beans, analyses 34
Roasting cylinder, Lehmann's 104, 105, 106, 107
„ , general precautions to be observed 105, 106
„ in the Dutch "soluble" method 181
„ the beans 103
„ , the purpose of 103
„ , „ temperature of 104

Page:
Roasting with coal . . . 104
„ „ superheated steam . . . 109
„ „ Dowson gas . . . 108
Roccellin . . . 96
Root bark of cacao, the use of . . . 12
Roll chocolate . . . 147
Roller machines, construction of . . . 131, 133
Roumania, the law on the trade in cacao goods . . . 238
Rüger's "solubility" method . . . 194

Saccharin . . . 81
„ cacao . . . 261
„ , detection of . . . 82
„ easily soluble . . . 81
„ , the harmless nature of . . . 81
„ , the use of . . . 81
Saw dust in cacao preparations . . . 233
Samples for cacao testing . . . 231
Salep . . . 85
Sand in cacao goods . . . 233
Saponification value of cacao fat . . . 41
Sesame oil in cacao fat . . . 44, 45
Seed membrane of the bean . . . 14, 15
Shaking table . . . 150
„ „ regulated by the number of revolutions . . . 156
„ „ with controllable mechanism, Lehmann's . . . 151, 152
„ „ , Lehmann's new form for readily liquefiable chocolate . . . 156
Shelled beans, analyses . . . 32, 33
Shell fat, investigation of . . . 43
Sifting the expressed cacao . . . 188, 189
„ machine, Lehmann's . . . 13, 189
Silicic acid in the ash of cacao . . . 69, 228
Six roller machine, Lehmann's . . . 134
Soconusco cacao characteristics . . . 18
"Soluble" cacao, chemical composition . . . 202
„ „ , chemical criticism . . . 199
„ „ , preparation of . . . 179
„ „ , properties of . . . 199
„ „ , rendering soluble, after roasting . . . 194
„ „ , „ „ , before pressing . . . 180, 181
„ „ , „ „ , chemical action . . . 179
„ „ , „ „ , Dutch method . . . 179, 180
„ „ , „ „ , German „ . . . 179, 196
„ „ , „ „ , methods of . . . 179
„ „ , „ „ , stages of the process . . . 179
„ „ , „ „ , Pieper's method . . . 180
Solubility, to ascertain the . . . 200
„ of cacao powder . . . 200
Somatose cacao and chocolate . . . 262
Sorting the beans . . . 101
Spices etc. addition of, to the chocolate mass . . . 125
„ , admixed with chocolate . . . 137
„ , chemical investigation . . . 93
Stamping mill . . . 80
Standard samples of commercial beans . . . 17, 18
Starch, cacao, granules of . . . 16, 59
„ , foreign in cacao . . . 60, 230
„ flour . . . 82
„ in cacao beans, determination of . . . 16, 59, 228, 230
„ in cacao, detection of . . . 60
„ in cacao goods, determination . . . 60, 228, 230
„ in cacao, iodine reaction . . . 16, 59

Page:
Starch in cacao, microscopy of the . . . 16
„ , microscopic detection . . . 16, 59
St. Domingo cacao, characteristics . . . 23
Steam plant, working cost . . . 210
„ roasting apparatus, Stollwerck's . . . 109
Stearic acid in cacao fat . . . 43, 45
Storing cacao preparations . . . 206
„ of chocolate articles . . . 207
„ „ the beans . . . 99
St. Thomé cacao . . . 26
Sugar . . . 75
„ determination, official method . . . 227
„ „ , Woy's method . . . 227
„ „ , Zipperer's method . . . 227
„ , excess in cacao preparations . . . 233
„ in cacao goods, determination of the amount . . . 226
„ flour . . . 76
„ in raw cacao . . . 64
„ pulverising machine . . . 76, 78
„ dust . . . 76
Superfluous moisture, after rendering "soluble", removal of . . . 197
Suppenpulver, definition of . . . 232
Surrogate chocolate . . . 232
Surinam cacao, characteristics . . . 20
Süssstoff, Höchst . . . 81
Sweet milk cacao . . . 258
Switzerland, the trade in cacao goods . . . 28, 239
Swiss "Lebensmittelbuch" . . . 239
Sykorin . . . 81
Sykose . . . 81

Tallow in cacao fat . . . 44, 45
Temperature for moulding . . . 147
„ of the cooling cellar . . . 157
Theobrominat . . . 94
Theobroma angustifolium . . . 13
„ bicolor . . . 13
„ Cacao Linné . . . 13
„ glaucum . . . 13
„ microcarpum . . . 13
„ ovatifolium . . . 13
„ silvestre . . . 13
„ speciosum . . . 13
„ subincanum . . . 13
Theobromic acid . . . 37
Theobromine and caffeine, separation . . . 51, 52
Theobromine . . . 48
„ , chemical constitution . . . 49
„ crystals in the tissue of the cacao bean . . . 16
„ combined . . . 49
„ , determination in cacao goods . . . 224
„ , decomposition in the animal organism . . . 50
„ , determination in the bean . . . 51
„ free . . . 49
„ , medicinal action . . . 50
„ , microscopic detection . . . 16
„ , physiological action . . . 50
„ , properties of . . . 52
„ , the amount in cacao beans . . . 54
„ , „ „ „ „ husks . . . 54
„ , solubility of . . . 52
„ , synthesis of . . . 49

Page:
Thesen's Proviant 262
Transport arrangement 208
Transport of live seeds 4
Tragacanth in cacao goods 219
Tin foil wrappers 206
Trinidad cacao, characteristics 23
Triple working mill, Lehmann's 120
Trituration of the cacao mass 119
„ „ „ chocolate mass, principles of 125
„ machine with rotating stones 125. 126
Tropaeolin 000 97
Tropon cacao and chocolate 262
„ -oat-cacao 262
Twin mill machine, Lehmann's 121

Unfermented beans 12
Uropherin 50

Vanilla 85
„ adulteration 87
„ chemical investigation 87
„ commercial kinds 86
„ crystals 89
„ eruption on the skin, caused by 87
„ treatment after gathering 86
Vanillin 88
„ , adulteration of 89
„ , consumption of 90
„ determination in vanilla 87
„ , detection of adulteration 90
„ formation in vanilla 85. 86
„ occurrence 88
„ , perfume value of 90
„ , prices of 89
„ -sugar, preparation of 90
Varieties of the cacao tree 13
Vascular bundles in cacao tissue 16
Vegetaline 43
Vegetable butter 43
Venezuela cacao 18
Vereinbarungen zur einheitlichen Untersuchung von Nahrungs- und Genussmitteln 248
Volatile alkalies, treatment with 199

Wacaca des Indes 263
Wallnut pulp in cacao 230. 233
Waste products in cleansing 116
Waste products in crushing and cleansing, chemical analysis 116
Water blue 97
„ in the beans, determination of 35
„ in cacao goods 218
„ power system 210
Wax in cacao fat 43. 45
Wheaten starch 83
Weighing cacao powder 201
White chocolate 263

Yellow (fast) 97

Zinc white in chocolate cigars 233

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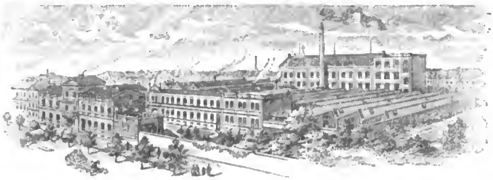

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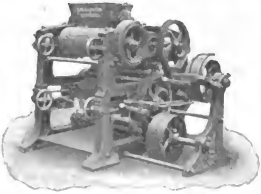

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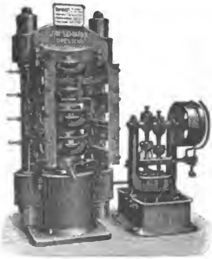

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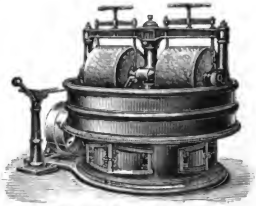

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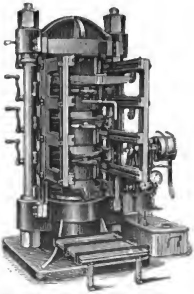

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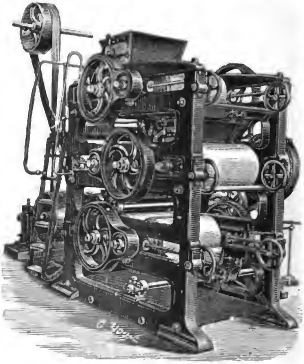

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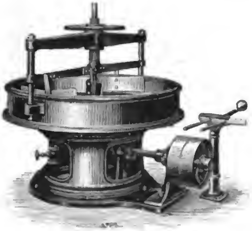

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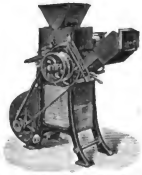

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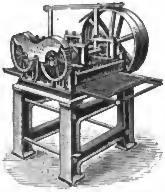

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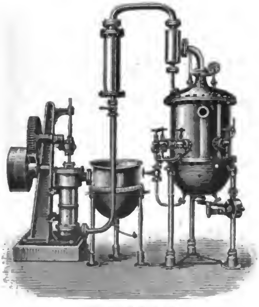

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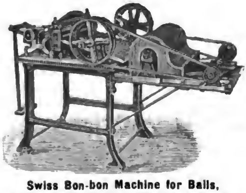

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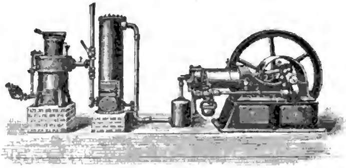

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